

Fuzzy IDEAS:
Using Fuzzy Logic to Make Sense of
Avant-Garde Music

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Certification of Originality

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Dedication

To my mother, Lauris, for encouraging my academic success; who always was, and would have been so proud of my achievements had she lived to see me complete this thesis and graduate, even though lack of finances meant she could not achieve her school-girl dream of going to university to study science; for always doing her best; and for her creative talents in making things work; her sewing, her poetry, and her love of singing.

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Abstract

Current approaches to understanding ‘art’ music have established procedures that address either the music or listener responses. However, the problem remains of simultaneously addressing the reality that music is intangible unfolding aural process that can only be perceived through listening along with the inescapable subjectivity of analytical decisions. In the late 20th century, computer scientists developed fuzzy logic to allow machines to imitate human thinking processes when solving problems involving imprecision and uncertainty. While fuzzy logic is designed to explicitly incorporate human subjectivity in decision-making, it did not initially have any connection with music. However, the principles underlying fuzzy logic suggest that this new procedure can be a useful and practical approach to creating visual representations of the multi-dimensional subjective nature of a single experience of listening. This innovation in music analysis can simultaneously address the twin challenges in musicology of ‘seeing’ relevant technical aspects of the music and ‘seeing’ listener responses as they unfold over time.

This thesis presents a new method of analysis, *Fuzzy IDEAS* (Fuzzy Inclusive Dialectical Expression Analysis System). This new method is designed to be transferable across different styles of art music and across listeners. Therefore, the new method bypasses the music score, yet is systematic while being extremely flexible and adaptable. Further, the new method is a broad open-ended approach to making sense of music on the basis of any idea, not only emotional response. This is particularly important in relation to avant-garde music because focussing on emotional response is too narrow.

Fuzzy IDEAS is a formalised method for making sense of an individual piece of music using qualitative information from a single personal experience of listening to this music. This method requires a transparent yet systematic way of documenting personal insights and technical observations while recognising that this will be incomplete and subjective information. This multi-stage process starts with conscious articulation of the implications of any information known to the listener about the music they are going to hear. The next stage is collecting the qualitative listening observations while listening to the music. Then the analyst uses the

principles of fuzzy logic set theory to convert these qualitative listening observations into fuzzified data, which is then converted into visual form. It is this visual representation of the experience of the music that is used to provide evidence for how technical aspects of this music suggests an idea.

Because *Fuzzy IDEAS* is designed to be inclusive, transparent, systematic and transferable across different pieces of music the new method is explained using my own experience of listening to four pieces of avant-garde art music. The data collection and coding methods have also been evaluated by using the method with three other listeners: a skilled composer, an enthusiastic listener, and another listener who dislikes avant-garde music intensely.

The findings show that *Fuzzy IDEAS* is an engaging, constructive and open-ended method for making sense of music composed using any materials, techniques and forms, and that *Fuzzy IDEAS* is transferable across information from a variety of listeners. This new method can thereby contribute directly to compositional pedagogy, and music appreciation. *Fuzzy IDEAS* opens the possibility of new data collection strategies for academic research into general listener responses, or to inform the marketing of Western art music. *Fuzzy IDEAS* also has promise for new technological applications to provide additional modes of listener engagement during concerts, contributing to audience development for avant-garde art music.

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Quick Reference Guide: Glossary of Terms

This Quick Reference Guide defines some discipline-specific terms used in this thesis. It is also a single place to find definitions of those terms I have developed for specific concepts embedded in *Fuzzy IDEAS*. These new terms have been initially explained in the body of the thesis, but recur without any accompanying explanation. This guide provides these explanations in one place.

Absolute Music: music considered to be free of extra-musical representation, without external references to emotions, sounds of nature, or objects or places. Absolute music aims to exhibit compositional skill through the formal and technical qualities of music. The term is used in contrast to Program Music, which is composed to depict pictorial ideas or external narrative.

Abstract Music: music which does not contain a vocal part, specifically there is no text embedded in the sound of the music. It is designed for no other purpose than as an aural artwork. My use of the term ‘abstract’ is entirely separate from philosophical debates about the mimetic possibilities inherent in instrumental music.

Acousmatic Music: music composed by manipulating sound elements on electronic equipment, perhaps tape recorders or computers, and then presented entirely without human (or robot) performers or conventional acoustic instruments. This music relies on PA systems and loudspeakers for its presentation in concert performances.

Amplitude: is the label I use for the attribute of music which acousticians call ‘loudness’ and which trained musicians typically call ‘dynamics’. However, in common usage, the term would be ‘volume’. ‘Loudness’ is a technical descriptor which is specifically associated with decibel (dB) measurements in acoustics, which only provides a static snapshot of loudness at particular time. While ‘dynamics’ indicates that loudness is not static, the label itself is confusing because it does not clearly refer to loudness. Music itself is an example of a ‘dynamic system’ over many attributes not only amplitude. ‘Volume’ is also ambiguous because it has other meanings in physical space. Although ‘amplitude’ is a technical term used in physics

to describe that aspect of a sound wave that fluctuates in loudness over time, it incorporates relativity over time while being potentially meaningful to a range of people.

Anacrusis: a technical term from music score notation to describe a single note, or a group of several notes, which leads into the first bar of the music. Aurally, an anacrusis occurs before the first accented event of the music or a section of the music. Anacrusis is sometimes called the ‘upbeat’ in reference to the gestures made by conductors to signify the timing of this series of events.

Art Music: is a broadly accepted term used in music discourse to distinguish music intended for concert listening from folk and popular music, as well as some forms of liturgical music. Art music can include many different styles of music ranging from early music to avant-garde. In conversation, the term ‘classical’ music is used when referring to art music, but this is technically incorrect as ‘classical’ refers to a particular style of art music composed during the ‘Classical’ period 1750 to 1830.

Associated with Partially Indeterminate Events: is the label I have given to a feature set of the attribute of Reflective Events. Individual events are classified into this feature set if one of the reasons it has come to conscious awareness is that the event is Partially Indeterminate. Partial Indeterminacy contains technical aspects of the indeterminacy of these individual events, while this feature set of Reflective Events contains the awareness that more is, or was, happening in the music than is, or was, available to conscious identification and enumeration at the time point of this Reflective Event.

Attentional Focus Time Point: is the label I have given to a feature set of the attribute of Reflective Events. Individual events are classified into this feature set if one or more aspects of the music grabbed attention by standing out in some way from the flow of the music and thereby making the listener much more alert to the actual qualities of the sound happening at that moment.

Attribute: is the general label for a specific parameter of music, rather than the fuzzy logic term of ‘Universe of Discourse’. Each attribute is described in more detail by some of its constituent feature sets. An example is ‘Event Duration’, which has several feature sets such as ‘Long’ and ‘Short’.

Auto-ethnography: is a qualitative research method, which inherently and necessarily incorporates personal experiences by using carefully designed techniques to acknowledge the presence and actions of the researcher to produce valid research results. Generally, the research is presented as case studies written as a narrative in which the researcher also writes with a personal voice and emphasises self-reflective activities to balance external observations.

Avant-garde Music: is music in which composers apply new or experimental ideas, designs, and techniques. This term has been in general use to denote new music that deliberately challenges traditional conventions of what constitutes art music, from techniques such as the existence of tonal centres, rhythm and melody, to values such as a composer with the desire to express universal truths. Music of 20th and 21st centuries is not the only avant-garde music.

Cadence: is a technical term from theory of tonal music which refers to those chord progressions which occur at the end of phrases, sections, and movements. These progressions are formed by various combinations of several chords which are significant in the tonal key in which the music is composed.

Classical Music: is a term which is technically only appropriate for music of the Enlightenment, i.e. music composed between 1750 and 1830 which features balance and elegance of proportion. Beethoven's music is often included in the Classical period, but his work pushed the boundaries of this style.

Coda: traditionally this term refers to an extra section of music designed to make the end of the music sound definitively conclusive through reinforcing elements of the immediately preceding materials.

Cognitive Event: the term used to describe, in general terms, any conscious product of the mind such as a thought, an image, or a memory. This is a garden variety definition of cognition, rather than a technical definition derived from the psychological literature. The purpose is to distinguish cognition from perception. In this thesis, perception is conceived as knowing physical phenomena through the physical sensation receptors of hearing or touch, for example.

Compositional Design: is the term used to encapsulate all those decisions made by the composer in the act of making each piece of music. Compositional design includes selecting the compositional techniques used to produce that music, sources of sound production, along with the temporal design of the sounds over time.

Computer Music: Computer music is an inclusive term that replaces both the older terms 'electronic music' and 'electro-acoustic music'. It also includes the possibility of using computers to generate conventional scores for conventionally played instruments. Computers are able to produce music with an enormous palette of timbres, ranging from old-fashioned 1970s' synthesisers to conventional instrumental timbres, to manipulations of digital samples of found sounds. Computer music is thus an inclusive term referring to any music composition in which computers are involved and which requires electronics as at least part of the means of sound production.

Emergent Feature Time Point: is the label given to a feature set of the attribute of Partially Indeterminate Events. Individual events are classified into this feature set when they come to conscious awareness with the specific realisation that this sound event has been occurring for some time. However, the sound has either not previously been apparent, or perhaps has been perceived as a background to other more significant sounds in the music, but now has become significant in itself. Examples of Emergent Feature sound events are a background hum, which suddenly becomes noticeable by its absence, or a high-pitched whistle-tone that begins so softly as to be imperceptible and gradually *crescendos* to the point where it is clearly audible and becomes notable. However, when these sounds actually start and/or stop is impossible to determine as the actual time has already passed. What is documented is the time at which the perception of these sounds becomes conscious.

Event Duration: is the label I have given to an attribute which refers to the relative duration of sound events. In some music, it may be more appropriate to replace Event Duration by Tempo, in recognition that it is not the duration of single sound events which are featured in the qualitative listening observations, but rather the number of sounds occurring within a period of time. Logically, if there are more sounds in a time period then each one must be relatively short, however, what

Tempo describes is the cumulative nature of a steady sequence of notes with identical durations over a fixed period of time.

External References Evoked: this is label I have given to a feature set of the attribute of Reflective Events. Individual events are classified into this feature set if there is something about the quality of the sound that evokes a thought of, or references the sound of, something else that has an independent existence in the extra-musical 'real world'. These types of references can range from 'a baby crying' which is made by a violin *glissando*, to 'sounds jazzy' because of the use of *slap pizzicato* on the double bass.

Feature Set: is the label I have given to any one of the fuzzy sets contained by an attribute. These specific feature sets provide more detailed categorisation and description of those aspects of sound deemed relevant to this attribute.

Free Range Thoughts: this is a label I have given to a feature set of the attribute of Reflective Events. Individual events are classified into this feature set at the time point when there is conscious awareness that thoughts have arisen that are quite separate from the music, even if they have been stimulated by aspects of the music experience. These events note the listener's subjective mental reactions to music as it unfolds. Examples of Free Range Thoughts include: feeling bored by the music, or wondering how the conductor is managing this tricky rhythm, or speculating whether this is the final sound event of the music.

Fuzzified Data: 'Fuzzified' is a term used in the fuzzy logic literature to denote that numerical data values have now been associated with a value of their membership in particular fuzzy sets. For instance, an amplitude precisely measured at 90dB, is 'fuzzified' when it is described as Loud with a membership value of 0.9, and Very Loud with a membership value of 0.2. In this thesis, fuzzification denotes the conversion of qualitative listening observations using the coding taxonomy into sound events with membership in feature sets and attributes.

Fuzzy Logic: was a term first used by Zadeh in 1965. It is a shorthand conflation of two concepts:

1. Fuzzy Set Theory, which posits that an object can be identified as belonging to (be an element of) more than one fuzzy set simultaneously, but with varying degrees of membership of each set. The degree to which the object is thought to belong to an individual fuzzy set is denoted as the membership value for that element in that set.
2. The Formal Symbolic Logic, or mathematical manipulations, by which various combinations of fuzzy sets are used to solve problems and make decisions, most often in automated systems, such as mechanised processes or artificial intelligence.

Fuzzy Set: is the label given by Zadeh to describe a type of mathematical set in which each of the elements have a two-part description. First, an object identifier, which might be a word, text label or a number that identifies that element; and second, the value with which that element is thought to belong to that specific set, known as that element's membership value.

Ideational Responses: refers to any ideas, thoughts or images of objects, or concepts, stimulated by the events in the music, as distinct from any of the physical qualities of the sound of the music noted by the senses.

Label: the human word(s), (alternatively 'term') used to denote and identify a specific aspect of a practical instantiation of fuzzy set theory to make that description comprehensible, i.e. relevant and meaningful, to humans.

Linguistic Variable: is a term from computer science, also used in fuzzy logic, to denote the type of label being given to the attribute under consideration. This term is used to denote that fuzzy sets labelled with words are being used in the calculations to represent the data rather than conventional mathematical symbols or numbers.

Map: is a term used in mathematics to denote a direct correspondence between the location of points in one domain and their location in another. Analogue clocks map time, as the hands continuously travel around the clock face indicating that time is constantly ongoing. The technical use of 'map' is a generalisation of what we

commonly use in everyday life: a paper map to navigate the physical world as we travel from one place to another. In common usage, 'map' has become shorthand for the paper diagram, rather than the mapping process which creates the paper diagram which reflects the physical world in which those distances and relationships actually exist. By comparison, road signs only point to locations; they do not directly represent the relative location of those points.

Membership Function: This is a label used by Zadeh in fuzzy set theory, to denote the entire collection of membership values for a particular fuzzy set. A Membership Function is an alternate way of describing a fuzzy set in mathematical symbols. This enables rigorous and precise mathematical calculations to be performed on the fuzzy sets. The notion of membership function is not often used in this thesis because I use simple arithmetic summations rather than calculations using algebraic formalisms. This is a possible further extension of my work.

Membership Value: is the degree to which the object is thought to belong to an individual fuzzy set is denoted as the membership value for that element in that set. Typically, for mathematical convenience, these values are set between 0 and 1, where a value of zero means that the element does not belong to this set, and a value of 1 means that the element completely satisfies all the requirements for membership of this set.

Multi-featured Events: are those sound events which are simultaneously classified in two or more feature sets within one attribute. In the visual representations Multi-featured events are denoted by multiple bars at the same time point, tied together with a double-headed arrow to highlight these sound events. The height of each bar represents the membership value for that sound event in that feature set.

Music Appreciation: a term used to refer to a listener's awareness of, interest in, and conscious attention to various aspects of music. Appreciation does not refer to enjoyment of the music.

Musicology: is a broad term which covers many aspects of in-depth study of music. Musicology thus includes music history and reception, ethnomusicology, music philosophy and art aesthetics, as well as music theory and analysis. Musicology can be distinguished from cultural studies or sociology which rely on the social context to give meaning to the music, rather than discussing the music itself. Musicology can be distinguished by its discussion of structure and other technical features of music.

Natural Language: is the language that we humans use when thinking, and to communicate with each other. Computer scientists also use symbolic languages such as algebra and machine languages for programming computers.

Notable Single Feature of a Multi-Attribute Event: is a feature set of the attribute of Partially Indeterminate Events. Individual sound events are classified into this feature set when the listener is aware there are multiple aspects to this sound event, yet has documented that one quality of the sound stands out as being notable. Examples might include a trumpet played in a high register is documented, yet there is an awareness of an orchestral accompaniment, or the crash of a gong stands out, yet there is an awareness of an audible cluster of percussion sounds. In these examples, while the sound event is documented as a Notable Single Feature event in Partially Indeterminate Events, the additional observation of a specific musical instrument would then also be documented separately in Sound Source.

Ordinal: is a mathematical term which describes the process of listing objects (or their symbols) in order of their relative status. Ordinal ranking does not require the object to have a precise numerical value. For example, sound events can be ranked in order from softest to loudest without knowing the precise dB level. Ordinal ranking is used across different mathematics systems as well as fuzzy logic. For instance, the 'median' average of a group of objects is that object located half way through an ordinal list.

Partially Indeterminate Events: is the label I have given to an attribute which contains cognitive events about the perception of particular features of some sound events as they occur over time. In particular, sound events marked as Partially Indeterminate Events contain some degree of uncertainty because of difficulty in determining precise time boundaries of the event. Although some uncertain events

arise due to the perceptual abilities of an individual listener, the composer may deliberately design the music to produce this type of uncertainty. Examples include masking some sounds by others for a certain time, or introducing a slowly evolving feature, or by highlighting other aspects of the sound of the music so that the listener's attention is drawn elsewhere for the time being. The three feature sets of Partial Indeterminate Events each contains one cause of indeterminacy. The three feature sets in this attribute - Notable Single Feature of a Multi-Attribute Event, Emergent Feature Time Point, and Uncertain Sound Source - are described in more detail in their individual entries in this Quick Reference Guide. A related feature set of Reflective Events records the impact on the listener of this sound event containing some extra yet unidentifiable information.

Pedal Tone: A long sustained, or frequently repeated, note that continues over a period of time, interspersed with other sound events that change and unfold.

Physical Sound Object: is the term I use for any sound that occurs in the real world. The label refers to the work of acousticians who define the physical aspects of sound to distinguish one sound from another. It is important to distinguish these measurable real world objects from qualitative listening observations which become Sound Events as defined in this thesis.

Presentation: is the term I use to denote the performance of music that generalises the concept of performance to new locations beyond the traditional concert hall stage, such as laneways and shops, while embracing new technical means of listening to music, such as through headphones streamed over the internet.

Program Music: Music inspired by an idea external to the music. This idea is referenced by the title, or other text associated with the music. Program Music is designed to portray a story, or natural events, rather than focussing on the abstract qualities of music. The term is often used in contrast to 'Absolute Music'.

Qualitative Listening Observation: denotes the initial information about their experience of the music documented by the listener while listening in real time. Qualitative listening observations are the most immediate record of their listening experience, including the time points of their observations and anything which occurs to them either ideationally or technically about the music.

Quantisation: is a term used in the digital representation and playback of music in music sequencers. Many music sequencers permit digital recording of MIDI data from a live performance as the initial material for the complete music yet to be created using the sequencer. Quantisation is an automatic adjustment of the input material to the nearest beat or part of a beat. The human user tells the computer how carefully the music is to be quantised and the computer does the work.

Recall of Similar Material (in this music): is a label I have given to one feature set of the attribute of reflective events. Individual events or a group of events are classified into this feature set at this point if there is conscious awareness of one or more aspects of the music, or similar combination of materials, having occurred earlier in this listening experience. Although, this realisation occurs at any moment during the repeated segment, it is only documented once at the time the thought occurs, no matter whether the repeated materials are ending, or continuing for some time.

Reflective Events: is the label I have given to an attribute which contains cognitive events related in any way to attention, recognition, supposition and ideation about the music as it unfolds in real time. I have determined five feature sets for inclusion in this attribute. These are: Attentional Focus Time Point, External References Evoked, Recall of Similar Material (in this music), Associated with Partially Indeterminate Events, and Free Range Thoughts. Each of these is described in more detail in its individual entry in this Quick Reference Guide.

Register: is the general label I use for the attribute of music that is related to the quality of sounds determined by the frequency and/or pitch level of the sound. However, the term is more general than 'pitch', which is clearly defined in relation to individual notes produced by acoustic instruments, while 'frequency' is also related to individual sounds produced by electronic instruments. 'Register' has the advantage of being generalisable across all types of music while, most importantly, it can be used to describe the quality of a series of sounds as well as an individual sound event.

Romantic Music: is the technical term for art music predominantly composed between 1830 and 1900, which is overtly designed to convey ideas such as nationalism; heroic struggle against obstacles; otherworldly events; expression of powerful emotions; individual genius; transcendence and ineffability.

Silence Event: is a type of sound event observed during the listening experience that consists of a notable silence, during which the music comes to a stop. Silence events are sometimes perceived as a point of closure, and other times perceived as a pause in the flow of the sound. Some Silence events are denominated by Silence only, while other Silence events can be associated with Reflective Thoughts and/or constitute a Partially Indeterminate Event themselves, depending on the aural context in which they occur. These additional attributes immediately infer that this Silence has some significance in interpretation.

Sound Event: is the generic term I have used throughout the thesis to denote occurrences in the sound of avant-garde music, similar to the way conventional instrumental music might be described as a collection of ‘notes’.

This sense of a basic unit of music is carried through to the generic name I have given the fuzzy logic entity that contains one individual qualitative listening observation. Some sound events may be described as Silences, while others may contain only a single sound in the music, e.g. a moment of microphone feedback. Yet, an important characteristic of a sound event is that that it may contain a group of sounds, conventionally described as a rhythmic or melodic motif or phrase. Thus a sound event may denote any group of sounds consolidated as a single qualitative listening observation by that listener.

Each qualitative listening observation contains any number of attributes or features observed by that listener. Reflecting on the multi-dimensional nature of music, the analyst can sometimes infer additional attributes from the qualities documented by the listener. However, these implied attributes are not included in the fuzzified data, or the visual representations of individual sound events, on the premise that it is what is documented that is the most significant, and therefore the most informative, aspect of the sound at that time to that listener.

Sound Production Method: the method of performance of a sound event. Each method impacts on the quality of the sound through enhancing or restricting the sounding of resonant harmonics, as well as the degree of overlap of individual sound events. For instance, a plucked note on a violin sounds very different from a bowed note with identical qualities of pitch, amplitude, register, and nominal duration.

Sound Source: a term that refers to the generating mechanism for the sound. It can be distinguished from, but impacts on the qualities of timbre and resonance. In conventional instrumental music, describing the Sound Source also identifies the Sound Type. This is not always the case with computer music, where at times, it can be nearly impossible to identify the generating mechanism, or Sound Source. However, it is nearly always possible to identify the Sound Type.

Sound Type: is the label I have given to that attribute of music concerned with the shape (amplitude envelope), timbre and resonance which combine to make particular sound types. Feature sets of this attribute can be labelled with conventional instrumental names, such as Flute, as this provides a succinct way of describing the Sound Type, yet others have been labelled with more unusual names, such as Rattling, which gives an approximation of the actual sound type, without the necessity of identifying the means by which the sound is produced.

Tempo: is the label I have given to that attribute of music concerned with how fast individual sound events are occurring through a period of time.

Texture: is the label I have given to that attribute of music concerned with describing the different layers or 'voices' that can be aurally distinguished within a given time frame, perhaps the whole of the music, or perhaps only a phrase. Texture describes the number of voices occurring simultaneously at any moment of time as well as the way in which these layers appear to be related to each other. For example, elaborating on the *Harvard Concise Dictionary of Music* (Randel, 1978:506) Texture that consists of two distinct voices is termed 'polyphonic' if both parts are melody lines, or termed 'homophonic' if one voice is a melody and the other is in chords. A Texture of four parts, each of which is a melody line will also be called 'polyphonic', whereas a Texture where there is only one part because every note is sounded simultaneously with three other notes, i.e. each sound event is a chord, is

described as 'monophonic'. Despite these general descriptions from music theory for 'Homophonic' or 'Monophonic', there are many different possibilities that composers use within each of these categories. Hence, the range of feature sets of Texture will frequently vary between one piece of music and another, which is one means of distinguishing different pieces of music from each other.

Tonal Music: is a generic term in musicological discourse. It is broadly defined here to describe music composed using a set of rules to organise the pitches of a scale into a hierarchy with one principle pitch, and possibly one or more subsidiary pitches, which become the focal points of the music. This hierarchy is used by the composer as the organising principle to structure the music harmonically and melodically. The boundaries of styles that can be comfortably described as tonal music are flexible. They incorporate jazz, baroque and early music, among others, but are distinct from music which does not give principal status to one focal pitch.

Transition Pairs: is the term used, particularly in machine-listening, to describe the variations between the attributes of every pair of adjacent sound events. This information contributes to assessing the formal design of the music by measuring the amount of continual variation, or direct repetition of events within the piece of music observed by the listener.

Uncertain Sound Source: this is the label I have given to a feature set of the attribute of Partially Indeterminate Events. Individual events are classified into this feature set if there is something about the quality of the sound that makes it impossible to identify the originating source of vibrations producing this sound. It could arise because several instruments in the music can produce a similar sound, or because the timbral quality is so different from the recognisable sounds normally produced by the originating sound sources that its origin is simply unidentifiable.

Universe of Discourse: is the label given by Zadeh to the broad information domain under consideration in a specific application of fuzzy set theory, such as the Amplitude of sounds at an airport. A defined Universe of Discourse is theoretically covered completely by constituent fuzzy sets. Theoretically, each fuzzy set contains every element of the particular Universe of Discourse to some degree. Yet only some constituent fuzzy sets are necessary for definition/labelling by the

investigator. Those fuzzy sets which are irrelevant to the investigation contain only elements each with a zero membership value because if a fuzzy set did contain any element with a membership value > 0 , then it would need to be part of the investigation and hence defined. Because fuzzy logic calculations do not require the inclusion of fuzzy sets with only zero membership values, it becomes unnecessary to define every feature set for a Universe of Discourse.

Introduction

Avant-garde music could be understood as practice-based research by composers¹ pushing at the boundaries of conventions in art music². Avant-garde music, including algorithmic and computer music, has brought a constellation of issues and assumptions regarding Western art music into the limelight. The nature of these individual challenges serves to highlight one or more of the fundamental qualities of music as an intangible stream of sound (which may include any number of silences between physical sound objects) occurring over time perceived subjectively by each individual listener as conveying an idea. However, established scholarship tends to gloss over the significance of these fundamental dimensions to understanding music as a particular, yet cohesive, artform. Thus, avant-garde music also challenges the conventions in which discourse³ on Western art music has been grounded.

This thesis introduces the *Fuzzy Inclusive Dialectical Expression Analysis System* (abbreviated as *Fuzzy IDEAS*). *Fuzzy IDEAS* is an original systematic method of listener-oriented music analysis designed to deal with the subjectivity of analysis and the diversity of individual pieces of avant-garde music. My new method is a broad open-ended approach to making sense of music based on any idea, not only emotion. This is particularly important in relation to avant-garde music because some of this music is not written with emotional responses as the primary idea, so focussing listener-oriented music analysis on emotional responses is too narrow.

¹ Composers are engaged in ‘practice-based research’ when they develop or apply new compositional techniques, presentation methods, or use of new sonic materials to produce new pieces of music and evaluate the aural results.

² Despite most people having experience of some style of music, they do not always have experience with some of the terminology; hence, discipline-specific terms such as ‘art music’ may not be meaningful to some readers. Please see the Quick Reference Guide: Glossary of Terms, which provides broad definitions of many technical terms like ‘art music’.

³ As outlined in footnote 4 (see p.4), it is difficult to precisely establish the boundaries of musicology as a discipline. However, in broad terms, musicology is academic study focussed directly on music as the object of study. Musicology is thus only one part of a broader music discourse that includes any text concerned with music, ranging from CD liner notes, to critical reviews of concerts and CDs in the mass media, to informal conversations occurring in concert halls and cafés, to academic texts in other disciplines that draw upon those researcher’s concepts of music in relation to their main question.

Fuzzy IDEAS addresses three overlapping problems facing new music in the 21st century: First, building broader appreciation of new music to encourage audience engagement with avant-garde music. Second, mainstream approaches to making sense of the aural experience of music are still seeking comprehensive answers to the problems of subjectivity and to music as an intangible, unfolding temporal process; and third, giving composers a means to test their music on one or more listeners for its communicative capacity. This new contribution to composition pedagogy encourages composers to actively engage with listeners' responses to their music. This will enable composers to consider whether and how their music has achieved their aims and/or how their music impacts on their listeners.

The full name of the new method, *Fuzzy Inclusive Dialectical Expression Analysis System*, indicates significant aspects of this new system of listener-oriented music analysis. If music is presented on a recording or in a concert, we know that this stream of sounds was designed by a composer to express one or more ideas through the medium of music. This does not assume that the idea is necessarily expressed elegantly or succinctly. On the other hand, the title of the music gives some guidance towards the idea, since, as Tagg notes, the title of the music suggests something about how the music is to be perceived whatever the circumstances of listening (Tagg, 2012:78). This new system for making sense of music addresses the ideas projected by the title, and investigates compositional design by using the perceived sound of the music as the locus of information, rather than relying on prior knowledge of compositional techniques or composer intention. As Tagg explains, there are many reasons composers do not accurately reveal their intention, or we simply cannot find out, including because the composer is dead or otherwise inaccessible (Tagg, 2012:196-198). Thus, we cannot truly know that idea before or after listening.

Fuzzy IDEAS is a dialectical method for identifying an idea that could inform the compositional design of a specific piece of music by asking how a stream of sounds, experienced by an individual listener in a concert-like situation, might make sense. There are two inter-related but different answers to the question of 'how' a piece of music makes sense. First, a specific idea works as a plausible key to understanding how an individual personal sonic experience holds together as an integrated whole

piece of music. Second, looking from the bottom up, we can analyse the individual aural perceptions documented during the lived experience of that stream of sounds to determine what technical features of this music were observed, and how these observed features work to suggest this idea. This search for an idea that informs the composition of a piece of music is not new; most music analysis is concerned to make sense of the music being studied. The real significance of *Fuzzy IDEAS* lies in using fuzzy logic principles to transform the unique intangible yet complex time-domain process of a lived personal experience of a specific piece of music into visual form. *Fuzzy IDEAS* is the result of two subsidiary research questions. First, how to implement fuzzy logic to characterise the potential range of technical attributes, including time and texture, with which a composer works to design music. Second, how best to provide in tangible form and consistent manner concrete evidence for how a single personal experience of the sound of the music makes sense across different pieces of music.

This is the first time fuzzy logic has been used to visually represent the human experience⁴ of listening to music. I make no claims that any technical events observed while listening can or will be observed by other listeners, nor that the idea that makes sense of that music for that listener is a common idea shared by other listeners. What I do claim is that my exploratory application of fuzzy logic to visually represent a personal experience of listening to music is a useful process for synthesising affect with technical details to explain how a specific piece of music makes sense, in a method that is repeatable and transferable across all types of avant-garde music.

Fuzzy logic provides a conceptual framework to systematically describe a single lived experience of a piece of music in entirely new ways. In the late 20th century, computer scientists developed fuzzy logic to explicitly incorporate human subjectivity when solving problems in complex environments involving imprecision and uncertainty. In particular, fuzzy logic set theory is useful for describing and classifying objects in music because the logic can work with incomplete information, therefore the model representation of a system does not have to be complete in order for the logic to work. Various computer scientists and technologically-

⁴ I refer to 'human listening' in contrast to 'machine-listening' (the digital analysis of audio files).

oriented musicians have applied fuzzy logic to problems in music, principally to investigate the possibilities of machines behaving like humans, so that computers can be ‘smart’ enough to autonomously solve real world problems such as composing emotionally appropriate film soundtracks (Whalley, 2002), or make digitally synthesised drum tracks sound realistically human (O’Sullivan and Boland, 2010). This work suggests that fuzzy logic is good for solving some problems in music. The original contribution to knowledge made in this thesis is the application of fuzzy logic to make visual representations of a human listening experience for the purpose of music analysis. This practical application of fuzzy logic is the substantial contribution of my research.

This thesis presents innovative exploratory research, to establish proof of concept that fuzzy logic can be applied to provide a systematic repeatable method of analysis, that relies on a single personal experience of listening and is transferable between different genres of avant-garde music. As other researchers have recognised⁵, the system of fuzzy sets in fuzzy logic seems *a priori* extremely suitable for describing the complexity of music. However, I studied fuzzy logic theory and its applications in other disciplines, and to other research questions in music, to discover how the principles of fuzzy logic might be applied in practice to form a systematic method of music analysis which recognises the subjectivity of analysis and music as an intangible time-dependent artform. This meant investigating how the principles of fuzzy logic could be implemented in a way that is comprehensive yet still intuitively make sense, as opposed to the abstract formalism of algebraic procedures, which is the hallmark of Western technical writing on fuzzy logic.

Flagging this new method as potentially ‘smart’ is no reflection on the intelligence of researchers in musicology or other disciplines. ‘Smart’⁶ is a term frequently used in

⁵ Chapter 3, Section 3.2, provides a complete review of existing applications of fuzzy logic to music problems. Briefly, the work most relevant to my research are proposals without any practical application, by several musicologists, for the use of fuzzy logic in music analysis, (Măniuț, 2010; Ciocan cited in Rădulescu, 2012; Heister, 2012a). However, fuzzy logic has been implemented by several computer programmers in their digital programming of machine-listening to a single melody line, but not music containing chords, in order to solve other problems in music related areas (Arcos and de Mantaras, 2000; Cope, 2005; Arcos, Guaus et al., 2013).

⁶ Japan was the first country to widely embrace fuzzy logic in engineering design of consumer products. Americans however, did not respond to the term ‘fuzzy’. Rather in fact, even engineers in the USA distanced themselves from fuzzy logic in technology research programs (McNeill and Freiburger, 1993:125). Western consumers, however, have responded to the sales pitch ‘smart’ as evidenced by

the 21st century in relation to machines that automatically perform complex functions⁷. *Fuzzy IDEAS* is similarly flagged ‘smart’ because my research is concerned with designing the schema for how such a ‘smart’ system can be conceptualised, as a necessary part of developing an automated system in the future. The new method presented in this thesis combines several functions, is systematic, and yet remains flexible and adaptable to circumstances as it relies on context-dependent decision-making, in this case, regarding how the sound of the music might make sense to the listener. This schema underlies ‘smart’ automated products and processes. Designing *Fuzzy IDEAS* with this ‘smart’ schema in mind provides the possibility of future automation into listener-oriented ‘smart’ music analysis.

The analytical process embedded in *Fuzzy IDEAS*⁸ begins with information about one listener’s personal responses in dialogue with the sound of the music. *Fuzzy IDEAS* exists in the liminal space between compositional decision-making and the reality of music as a lived experience. My innovative practical application of fuzzy logic to visually represent the multi-dimensional subjective nature of an individual experience of listening is inclusive on several levels. As shown in the demonstration analyses⁹ this systematic method incorporates the complete range and complexity of sonic variables through which a composer works¹⁰ (it is not simply focussed on

the continued use of this term for machines such as smart phones, and the continuing sales of these products.

⁷ ‘Smart’ phones integrate several functions seamlessly. For instance, on the press of a single button when taking a photo, four different tasks are performed. The photo is: (1) formatted to a predetermined file size, (2) corrected for the lighting conditions and is (3) automatically focussed on (4) smiling faces. Rice cookers are another type of ‘smart’ device which ‘know’ when the rice is cooked and turn off, another example of context-dependent decision-making programmed into a machine.

⁸ The best summary of the method can be found in Table 4.1. The Stages of *Fuzzy IDEAS* (pp. 117-120) in Chapter 4. *Fuzzy IDEAS: Listener-Oriented Music Analysis*.

⁹ See Appendices A-D (pp. 275-436), particularly in Appendix D. *Fuzzy IDEAS* applied to *Concert for Piano and Orchestra* (Cage, 1957-58) where Figures D.1-D.9 (pp. 398-402) show a very broad range of attributes are captured for this music.

¹⁰ Arnold Schoenberg’s text *Fundamentals of Musical Composition*, despite being a text book for first year university composition students with examples given in piano score form, initially includes what he calls “...the basic building blocks” of melody, harmony, rhythm, pitch, contour, metre and tempo (Schoenberg, 1967:3), but in later chapters includes texture, and timbre (sound source) (Schoenberg, 1967:82), register, volume and timbre (tone colour) (Schoenberg, 1967:98). I have labelled the technical attributes of music with the broad terms: Register, Texture, Timbre (Sound Source), Amplitude, Event Duration and Time. There is a more substantial discussion of my terminology for technical attribute in later parts of the thesis, see pp. 175-177 and pp. 185-186, however, it is important to recognise that other composers may use different terms. For instance, computer music composers may choose alternate terms such as frequency, harmonic spectrum, and onset times, while instrumental music composers might choose alternative terms such as pitch, tempo, rhythm. However,

pitch or rhythm), and integrates personal perceptions of the sound of the music. The visual representations simultaneously capture multiple dimensions of music and their impact on that individual listener's experience by deliberately including subjective cognitive responses as well as technical information perceived by the listener¹¹.

The method is inclusive of whole pieces of music and is inclusive of all styles of avant-garde concert music. Importantly, *Fuzzy IDEAS* is inclusive of all types of sounds and structures, and all types of personal responses. This inclusivity is enabled by using fuzzy logic principles throughout the design of *Fuzzy IDEAS*. Although there are earlier proposals to use fuzzy logic as a means of musicological enquiry¹², *Fuzzy IDEAS* is the first detailed application of fuzzy logic in this new method of listener-oriented music analysis. Indeed, an innovative contribution to knowledge made in this thesis is the practical application of fuzzy logic to qualitative music analysis in a way that is consistent and transportable across different types of avant-garde music. The method is pre-determined, the content of the qualitative listening observations and the resulting fuzzified data varies from listener to listener and music to music.

Fuzzy IDEAS is designed as a method for analysing autonomous avant-garde music that does not contain text or recognisably meaningful words. It is impossible to find a single term¹³ which can be clearly understood to include Western art music composed using sounds from acoustic instruments and/or 20th century inventions such as synthesisers or samplers with real world sounds. Conventional music terminology would describe music that is autonomous from text as 'instrumental' as opposed to 'vocal'. However, *Fuzzy IDEAS* is designed to work with computer music

I suggest that composers from both schools are referring to the same basic attributes but are using the terminology most appropriate to their means of controlling sound production. I suggest that even if a composer chooses to limit their palette by keeping one or more of these attributes as static and unchanging, the production and organisation of sound into music requires all these attributes to be in place to some degree. In fact, that compositional decisions to about how, what, and when to emphasise one or more of these attributes is what distinguishes one piece of music from another.

¹¹ Each of the demonstration analyses presented in Appendices A-D shows these technical and cognitive attributes in summary form in Figures A.1 (p.284), B.1 (p.323), C.1 (p.360), and D.1 (p. 398).

¹² References to this previous work with citations can be found in footnote 5 (see p. 4).

¹³ Perhaps abstract (?) absolute (?) ambient (?) or acousmatic (?), but each of these has alternative and different functions in their present roles as descriptors of types of Western art music.

and acoustic music designed for concert-style presentation. Even though the problem of understanding autonomous Western art music is not confined to avant-garde music, it is exacerbated by the distinctive qualities of avant-garde music as composers push the boundaries of music beyond the use of known and familiar sounds and structures.

Fuzzy IDEAS is not designed as a general theory that human listeners respond in particular and predictable ways to given music stimuli¹⁴. Communication theories of prescribed meanings that are always conveyed by specific qualities of music rely on a shared understanding of signs and symbols in the music, which point to fixed meanings understood by both composer and listener. Establishing the value of *Fuzzy IDEAS* does not require the type of experiments which test for statistical validation of the method because *Fuzzy IDEAS* is not a broad theory of communication of fixed meanings through music, such as the semiotic theories developed by Tagg (2012) for popular and film music, and Nattiez (1990) for art music. *Fuzzy IDEAS* is not concerned with identifying specific formations in music that could be interpreted as this type of sign, given a common interpretation by people with similar cultural backgrounds. To make this type of claim about general perception and reception of music events would require empirical testing using statistically valid and reliable experimental methods; however, this is not the purpose of *Fuzzy IDEAS*. It is possible that *Fuzzy IDEAS* could be useful in this type of predictive testing, but this too could only be established by statistically valid experimental research testing *Fuzzy IDEAS* on a variety of users. Rather, *Fuzzy IDEAS* is a method of music analysis designed to make sense of avant-garde music that relies on information from a single listening experience. Rather, *Fuzzy IDEAS* is assessed by discussing the value of the system on its own merits, especially the impact of its design and implementation. I have conducted a small study to evaluate the utility of the method when using information from other listeners as input to the

¹⁴ As will be discussed throughout this thesis, this thesis is not about music and emotion. My concern in this research is with the ideas stimulated by pieces of music in their entirety. Further, I am not concerned to find any general connection between formal design and listener interpretation. The strength of this new method lies in its reliance on individual perception of the sound of the music as a useful way of finding an idea for making sense of the music. These ideas may include anything that comes to the listener's conscious awareness, including but not only emotional responses.

analytical method. This evaluation establishes proof of concept that the method produces useful results.

Although *Fuzzy IDEAS* has potential as an inclusive method for making sense of any type of ‘difficult’ music, it cannot avoid being grounded in the aesthetics of Western art music, because that is my background. As will be discussed in more detail in Chapter 2, Section 2.2, the two main impacts of this aesthetic are the assumption that music without words is meaningful and thus has value, and that this type of music can and does make sense because it conveys ideas. Although it is assumed that avant-garde music is not composed on principles of functional, or tonal, harmony, the generalised design of the new method, by allowing relatively free description of what is heard during listening experience, means that Western tonal music is not excluded from potential consideration. However, I make no claims for *Fuzzy IDEAS* outside of Western avant-garde music, since this is the music that *Fuzzy IDEAS* was designed to examine. Perhaps Western analysts could use *Fuzzy IDEAS* to make sense of the music of other cultures from a Western perspective, but ‘ideas’ and ‘sense-making’ may not necessarily be the perspective of those cultures from which that music emanates, nor the reason for composing that music. Consequently, the application of *Fuzzy IDEAS* to the music of other cultures may not be appropriate within those cultures. This thesis therefore only addresses Western art music composed in the late 20th and early 21st centuries.

This thesis presents practice-led research. The design of *Fuzzy IDEAS* firmly reflects my insights into music as a composer who is required to make manifold decisions about multiple aspects of music when designing an aural experience for listening. My own experiences of composing and listening to avant-garde music have significantly influenced the design of *Fuzzy IDEAS*. Therefore, I am including a brief biographical description as a background to the research in this thesis.

Before my formal music education, I obtained a Master of Arts (Hons) degree in economics and mathematics from the University of Melbourne and worked in management information systems and program evaluation for non-government organisations and the Australian Government. I successfully auditioned for Bachelor of Music playing flute, and then majored in acoustic and electronic music composition at La Trobe University, which specialised in the study of contemporary

art music. Due to the closure of the music department at La Trobe, I completed my Honours year at Elder Conservatorium of Music, a traditional conservatorium specialising in performance of mainstream art music. During my honours year, I won the inaugural South Australian Piano Trio Competition with *Carlin*.

My research for Master of Creative Arts in computer music composition at the University of Wollongong, a specialist department in micro-tonal electronic music, involved using algorithmic compositional techniques in computer music and acoustic music for voice, which contained text, either sung or spoken.

During the first year of my doctoral candidature I was awarded the 2009 Fellowship of Australian Composers Postgraduate Composition Prize for my electro-acoustic music without text: "*the sea leaves ear-shells...*". During the first years of my doctoral candidature at the University of Wollongong I worked as a research assistant developing individual reflective practice and peer-to-peer critical assessment methods for undergraduate singing students. I also worked as a project officer evaluating curriculum and outcomes of undergraduate courses in creative arts for meeting the broad educational goals set by the university.

Following closure of the music department at the University of Wollongong, I transferred my doctoral research to the Australian National University, a more traditional conservatorium-style music department. During my candidature, the department was reviewed and revamped, losing over 70% of staff positions while existing staff were entirely replaced. There is no longer any temporary work available for postgraduate students in music. I have significant personal experience of the challenges that face musicians in academia.

In addition to research for this thesis I composed concert music and soundscapes to accompany art exhibitions and had publication of my scores by Redhouse Press and Publications by Wirripang. ABC Classic FM has broadcast *Carlin*. My music has been performed around Australia and the USA in a wide variety of settings from art galleries and dedicated concert spaces to cafes and outdoor performances. My music is included on CDs of Australian flute music, Australian chamber music, and Australian computer music. I am a represented composer at the Australian Music Centre. I am also a community musician: as inaugural Musical Director of POW

Circus, Melbourne, for six years; and as composer in residence at the Jika Jika Community Centre, Melbourne. I have been a regular workshop presenter at the Darebin Music Feast and other music festivals, where participants played my music specially composed for the Federation Bells commissioned by the Victorian Government for the Centenary of Federation. In 2013, I was Composer in Residence for the National Rural Women's Coalition during the Centenary of Canberra celebrations. All these experiences have impacted on my research, directly and indirectly, from research question to final solution: *Fuzzy IDEAS*.

As Babbitt argues, research by practice is necessary for the development of music as a discipline or else it will simply stagnate (Babbitt, 1958). This statement also holds true for the development of musicology. We can see this has been the case since musicology was first recognised as an academic discipline. As documented in *Grove Music Online*, musicology as a distinct scholarly discipline was not recognised until the second half of the 19th century, even though music was studied before that time as part of general scholarship (Duckles and Pasler, 2014). This attests to the continuing evolution of the 'science' of musicology from the Ancient Greeks. Unsurprisingly, as Duckles and Pasler explain, there have been further refinements and development of sub-disciplines up to the present day. The work presented in this thesis continues this tradition.

Background philosophical questions about the nature of music influence the design of the method, while the development and precise format of *Fuzzy IDEAS* has been informed by the experience of listening to the music for each one of the four demonstration analyses and the associated writing up of that experience¹⁵.

Collecting information for the demonstration analyses was illuminating in terms of being introduced to music previously unheard by me, and also simply noting how much the collection process added to my awareness of the nuances of the sounds and consequent overall enjoyment of the music. Further, the process of writing up the listening experience based on my real-time qualitative listening observations, followed by the analysis of the visual representations to find evidence for possible ideas behind each piece of music, was an illuminating exercise. This deeper consideration of the experience of the music brought into the foreground aspects of

¹⁵ The four demonstration analyses can be found in Appendices A-D (pp. 275-436).

the sound of the music and associated framing information such as the title. The writing process, by collecting and sifting through evidence to make an argument, brought out the way that each string of sounds called ‘a piece of music’ could make sense.

However, it took quite some time to work out the best way to completely write up the demonstration analyses so that they might make sense to a reader unfamiliar with fuzzy logic, while maintaining auto-ethnographic integrity¹⁶. Unsurprisingly, the four pieces of music presented varied listening experiences, as the sound of the music and its unfolding was different. Each demonstration study contributed something to the development of *Fuzzy IDEAS* throughout each trial of the method. Sometimes the qualitative listening observations showed something unique but important to one piece of music that could be usefully incorporated into the whole method. Alternatively, differently sounding music sometimes replicated similar perceptual experiences. It became clearly important to think about which details in the qualitative listening observations pointed to what aspects of the sound made this piece of music different, as well as those aspects of the sound that were the same as the other music. Each study contributed to finding the means to highlight these small variations, which have large effects when listening, and thus on making sense of the music. Thinking about the listening notes and how to represent that documented experience, and how best to represent the sense-making process, meant reviewing previous write-ups of the other demonstration analyses several times in light of revelations from the one at hand.

It was clear that the qualitative information about the music would be represented by fuzzy sets. However, in every demonstration study, most differences documented in the qualitative listening observations, then to be reproduced in the visual representations, were quite subtle variations in the sound of the music as it unfolded over time. The challenges were in creating the complete set of visual representations and analytical charts in a form that could be consistent across different pieces of music, while highlighting the apparently small variations between

¹⁶ The principles of auto-ethnographic research are discussed in more detail in Chapter 4, but in summary are about including a critical self-reflexive account of the researcher about their interaction with the research materials, and the impact this may have on the data collection and consequent results.

some pieces of music. This meant clearly establishing the hierarchy of the qualities of individual sound events as they were experienced and documented while listening, so that these differences and similarities in sonic qualities could become tangible in visual form¹⁷.

Partially Indeterminate Events evolved as important in their own right, while Silence Events turned out to be not just simple absences of sound but depending on the context in which they occurred, could become more complex cognitive perceptions particularly in relation to the purpose of these moments of silence. Another instance is Texture. It became apparent as each study unfolded that Texture takes on many different qualities in music without conventional melodic lines or harmonic progressions. These differences in quality can be hard to describe meaningfully in few words although they make a big difference to the aural quality of the music. Text descriptions of a complex experience can easily skim the surface of the experience to maintain readability, or if aiming to provide realistic detail become convoluted and difficult to follow.

I conducted these four demonstration analyses (see Appendices A-D pp. 279-437)) to investigate how fuzzy logic principles could be applied to classify the qualitative listening observations documented during a single personal experience of music. Also, how best to visually represent these complex details of an aural experience of music in a form that includes any type of personal responses¹⁸, and the impact of the passing of time. The method has been tested on three other listeners to evaluate its broader application. The result is the first practical implementation of fuzzy logic in a method for making sense of complete pieces of music, which is repeatable across music of varying materials, forms and compositional procedures.

The demonstration analyses establish the concept that fuzzy logic works to provide valuable insight into how the sound of the music makes sense. This new method

¹⁷ For example, Figures A.1- A.7 (pp. 284-287) show the hierarchy of the qualities of individual sound events as they were experienced, then visually represented in Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984). These can be compared with Figures B.1-B.7 (pp. 323-326) in Appendix B. *Fuzzy IDEAS* applied to *Women in Transit* (Hope, 2004). This comparison illustrates how differences in the music show as differences in the fuzzy entities and hence the visual representations.

¹⁸ As will be discussed in more detail in Chapter 2, personal responses may include, but not necessarily be confined to, emotional reactions. This thesis is not about the connection between music and emotion, but rather views emotion as one possible ideational response to listening to music.

uses fuzzy logic to convert qualitative listening observations into ‘fuzzified’ data¹⁹ that is then used visually to represent a single personal experience of listening to Western avant-garde music. This visual representation captures the complexity of this intangible aural experience of a single piece of music, including the impact of time. In summary, to remain true to the idea of personal response driving the method, the fuzzified data and consequent visual representations in *Fuzzy IDEAS* builds on the metaphor of music as a physical sound object²⁰. Compared to text-based descriptions, and representations using mathematical formulae, this visual representation provides a transparent²¹ platform for investigating how that specific music makes sense.

Because the visual representations are grounded in fuzzy logic, this systematic method of description is transportable although the final outcome of each individual analysis is not claimed as a definitive result across all listeners. So the framework remains consistent when applied to different music, as demonstrated in the analysis of four different pieces of music in Appendices A-D (pp. 279-437), and the testing on different listeners in the evaluation study described in Appendix I. (pp. 493-512). *Fuzzy IDEAS* is, however, a way to make sense of this music that is a synthesis of technical information about the material design of the music along with the subjective ideational responses those materials stimulate in the listener.

Music analysts still have difficulty in using the lived aural experience of a stream of sounds for making sense of a piece of Western art music. Thus, as Whalley asserts, musicology is saturated with the assumption that “...all listeners will be as fully cognisant and musically attentive and as informed as the composer having

¹⁹ ‘Fuzzified’ is a term used in the fuzzy logic literature to denote that numerical data values have now been associated with membership values in fuzzy sets. For instance, an amplitude precisely measured at 90dB, is ‘fuzzified’ when it is described as Loud with a membership value of 0.9, and Very Loud with a membership value of 0.2.

²⁰ I use the term ‘physical sound object’ to describe any one sound that occurs in the real world. The label refers to the work of acousticians. The term ‘physical sound object’ distinguishes these real world occurrences from sound events in music, which are defined in this thesis as essential building blocks for *Fuzzy IDEAS*.

²¹ I use ‘transparent’ to denote that the information is visible, it is presented directly on the page or screen, and is available for visual scrutiny. This does not necessarily mean that the information is readily comprehensible. Although immediate comprehensibility is my aim, all readers are not necessarily comfortable or familiar with complex charts. My main reason for using ‘transparent’ is in contrast to mathematical formalisms, or esoteric music theoretic symbols and terminology.

completed the work” (Whalley, 2000b:151). Methodically analysing that intangible individual subjective aural experience that we know as music is challenging. Many of the basic questions addressed by my research are not new, yet comprehensive answers prove elusive. Current approaches to music analysis use a variety of procedures to address different genres of music, as well as ways of dealing with the inherently inescapable subjectivity of analytical decisions.

There are many methods of music analysis explained in the musicological literature. Although these branches of musicology use different theoretical approaches, they typically use similar case-study methods to draw conclusions about particular types of music. However, they can be broadly considered as two distinct methodologies. According to Duckles and Pasler, musicology has been codified into two major streams since the end of the 19th century (Duckles and Pasler, 2014). These two streams, each of which tends to be associated with a particular research methodology, can be seen as different approaches to addressing the two core problems of music analysis: the inescapable subjectivity of analytical decisions²² and the complexity of music as a time-based intangible multi-dimensional artform.

The first stream is concerned with the historical aspects of music such as the evolution of notation, instruments, compositions, and developments of form. The second stream has traditionally been described as ‘systematic musicology’. Systematic musicology addresses fundamental questions about music that are non-historical in nature. These include aesthetics and research into the nature and properties of music as an acoustical, physiological, psychological and cognitive phenomenon. Systematic musicology investigates any aspect of the actual music and the people involved in its making, including the existence and purpose of particular theoretical aspects of music; or the psychology of composing, listening, or performing; the teaching of music; and the comparative study of music from other cultures. Duckles and Pasler note that a systematic approach can also be given to historical areas, such as “...a semiological approach to musical notation and

²² As will be discussed in Chapter 4, Section 4.4, Marion Guck argues that even with formalist analysis, the subjectivity of the analyst is still revealed by the way they write. I also observe that even machine-listening, which enables analysis of large numbers of individual music notes and their relationships, still incorporates some subjective judgement of the analyst-programmer. Therefore, although some programmers label the results of their work ‘objective’, even the so called ‘objective’ methods of machine-listening, contain human subjective elements (see Chapter 4, footnote 15, p. 140).

typological classifications of musical forms (Duckles and Pasler, 2014). The promise of modern tools developed in other arenas to enhance the work of systematic musicology has been discussed by Parncutt (2007). One such tool is statistics-driven experimental design, which aims to provide evidence for generalisable results, thereby ‘scientifically’ establishing the accuracy of propositions about the effects of music and patterns of listener responses to given music stimuli²³.

Even though both methodological streams provide interesting and useful insights into the specific technicalities of a single genre of music or to general patterns of listener responses to discrete elements of music, they still do not provide a systematic yet transferable process for making sense of the sounds of any piece of Western art music. My new method draws on both major methods of musicological enquiry. *Fuzzy IDEAS* operates on the case-study principle of drawing qualitative information from a single experience of a specific piece of music, and draws on the strengths of the empirical experimental method in which the method itself is applicable across multiple test-cases even if each test-case produces different results. Experimental methods enable transferability by setting out method and materials, clearly and explicitly.

These experiments are designed to remove the individuality of response, thus supposedly eliminating the problem of subjectivity and thereby establishing ‘objective’ truth. As will be discussed in Chapter 4, the inductive logic underlying this science method cannot reveal the absolute truth of propositions, it can only disprove incorrect suppositions. More importantly, in relation to the present point, applying statistical methods to document human activity does not necessarily remove the subjective bias of either the research or the researcher. *Fuzzy IDEAS* includes these biases, at the very least implicitly, if not explicitly, in the documentation of personal responses during the listening experience.

Because music is a multi-dimensional abstract ephemeral intangible artform, it is hard to provide concrete evidence for assertions. The main point of distinction

²³ See for example, Parncutt (1999) “Perceiving musical tension in long chord sequences” *Psychological Research*, 62, pp. 237-254. Further, as neatly summarised by Julie Rickwood’s overview of statistical research into community music-making: “...we need to ensure that it is the full experience [of music] we are attempting to explain, and not some conveniently simplified portion of it...whose impact...can be measured, predicted and controlled” (Rickwood, 2013:85). The ‘ecological validity’ of experiments and the utility of their results are discussed in more detail in Chapter 2 (see pp. 63-89 below).

between *Fuzzy IDEAS* and the work of other researchers is my use of detailed visual representations of one hearing of the sound of the music as experienced by one listener, to include the subjectivity and richness of an individual response to a piece of music as it unfolds over time. As Guck observes, music analysis struggles with the “...immaterial, enveloping, evanescent nature of musical sounds. They are all around us and most intensely within us, but not, except as represented in scores, in an immutable form that we can examine...[rather] the musical work lies...just out of reach...after the fact...catch as catch can...it reflects what the interaction with music is like”(Guck, 1994a:228). Secondly, as Cook and Dibben suggest, further difficulty lies in describing those attributes of the music which are used to understand that specific music “...while at the same time conforming to the requirements for inter-subjective intelligibility in the absence of which writing about music becomes a critical free-for-all where anything goes” (Cook and Dibben, 2010:69). Despite the long development of music theoretic terminology to refer to qualities of the sound of the music²⁴, it seems that the subjectivity of the personal experience of listening, and difficulties in its portrayal, has led to analysis of Western art music operating outside the aural impact of the music.

The aim of my research has been to develop a well-defined transferable method so that the music being studied can come from any genre, from chamber music to computer music, but the analytical method remains the same. My demonstration analyses show that because of my classification framework based on fuzzy logic, the resulting visual representations of the two intangibles, music and personal response, can be consistently applied to a variety of Western avant-garde music. Further, the evaluation demonstrates proof of concept that it is possible to make sense of music using a single listener’s qualitative listening observations. Avant-garde music can be particularly difficult to analyse with an identical transferable method because, as Babbitt identified 50 years ago, each piece of music needs to be taken on its own terms (Babbitt, 1958). As Vella explains, each individual piece of avant-garde music contains one or more new compositional tools and techniques, originating sound sources, overall temporal design, and/or presentation methods

²⁴ Music theoretic terminology exists for individual sound events, such as *diminuendo*, *sforzando*, and for groups of events such as ‘phrase’, as well as names for the formal structures of music, such as *rondo*. Like any other discipline, this jargon developed so that musicians can easily communicate with each other about the particular qualities of various aspects of music.

(Vella, 2000:84). As Landy recently observed, methods developed to analyse computer music are frequently not applicable to more than one piece of computer music, let alone across genres to acoustic music (Landy, 2015:6), while the reverse is also frequently true. Despite the apparent limitations of *Fuzzy IDEAS*, this discussion suggests that *Fuzzy IDEAS* is a useful way to use qualitative listening observations to analyse and make sense of any unconventional and 'difficult' Western art music.

I use the term 'avant-garde' as a shorthand way to describe 20th or 21st century music in which composers apply new or experimental ideas, designs, and techniques. Wilson describes the meaning of the term 'twentieth century music' as music composed during the 20th century, which, although using new techniques, did necessarily confront important 19th century conventions of music such as unified structure, individuality, and autonomy from social function (Wilson, n.d.). My use of 'avant-garde' is a pragmatic alternative to using Wilson's term 'twentieth century music' since we no longer live, compose and listen in the 20th century, and 21st century music is not yet a defined style. Other terms have also been used to denote new contemporary art music but are not as useful as the term 'avant-garde' in distinguishing unusual music, while being more confusing.

During much of the 20th century, the term 'contemporary music' was used to denote the latest trends in music. This is exemplified by the International Society for Contemporary Music founded in 1922 which, as Haefeli and Oehlschlägel document, was highly prominent in promoting 'contemporary' art music (Haefeli and Oehlschlägel, n.d.). However, with increasing academic attention being given to popular music, the term 'contemporary music' is now more often associated with popular music. The confusion this is causing is indicated by the elaborate title of a recent conference paper "Bridging the Gap: Thoughts on Computer Music and Contemporary (Popular) Music" (Keith, 2010). The alternative term 'new music' was associated with innovative compositional techniques of some well recognised composers in the late 1920s right through to the 1950s and later (Good and Nicholls, n.d.). As noted by Good and Nicholls, in practice all three labels represent the music of recognised composers, such as John Cage, because the music of each composer did not neatly fit into only one category. Additionally, these different terms were used at similar time periods and thus became interchangeable. Even though in the 21st

century the terms are confused and no longer as meaningful as they might once have been, I will occasionally use them to denote music that pushes and changes the boundaries of music. However, 'avant-garde' remains the simplest and most evocative description of 'difficult' music that may have emanated from any one of these compositional perspectives.

'Avant-garde' is sometimes used to describe only music composed to challenge the social organisation of music performance practice, and the cultural expectations attached to concert music. For instance, Kramer (2002:xv) insists that to be avant-garde requires an intention to challenge the musico-political status quo, rather than simply being innovative for its own sake. Samson and Kramer each argue there is no longer a technically discernible avant-garde scene because the avant-garde was eventually overtaken by the post-modernist movement in which anything became possible (Kramer, 2002:xvi; Samson, n.d.). Nonetheless, Kramer argues that in musicology at least, avant-garde can be distinguished from post-modernism because avant-garde composers are still pushing at the boundaries of what is known and accepted as music (Kramer, 2002:xvi). Similarly, Keith writes that 21st century computer music emphasises research and experimentation, thereby "...continuing in the Western avant-garde and art music traditions" (Keith, 2010:37). Thus, Kramer and Keith each demonstrate that 21st century musicologists still associate the ideas of rebellion and pushing out of boundaries with the term 'avant-garde'. I am happy to join the throng of authors using this term in its loose sense to describe a wide variety of Western art music that is practice-based research into new compositional techniques and applications of new concepts and technology.

I am using 'avant-garde' as a catch-all term to describe any Western art music which challenges those conventions of tonality established during the 'common practice period'²⁵ which, as Babbitt describes, came to be seen as 'musical absolutes' or

²⁵ Babbitt here follows common usage of this term as a means of distinguishing contemporary art music from tonal music composed between 1600 and 1900 based on principles of so-called 'functional' four-part harmony grounded in the bass line. However, like most things in music, it is difficult to clearly establish the boundaries of the 'common practice period'. Notably, this term cannot be found in major music dictionaries, thus important reference texts do not define this as a distinct historical era. There are a variety of interpretations in academic literature, such as those found in Cook, N. (2004) 'Making music together, or improvisation and its others' in *The Source: Jazz Research Journal*, Vol. 1, pp.

necessary attributes without which music simply does not exist (Babbitt, 1958). Typically, each piece of avant-garde music is different from other pieces of avant-garde music. Avant-garde music has little repetition of materials, and many complex individual sound events, while the principles on which sound events are related to each other differ in each individual piece of music. Thus, as mentioned previously, avant-garde music is not a 'common practice' but rather, as Babbitt observes, "...a variety of universes of diverse practice" (Babbitt, 1958). The question then arises of how to make sense of the sound of a piece of music that does not follow convention.

'Musicology' is a broad term that covers many aspects of in-depth study of music. Tagg makes an important distinction in his discussion of academia and music (Tagg, 2012:83-132) and his definition of musician (Tagg, 2012:595). In summary, musicology can be distinguished from other academic disciplines which also address the question of how music 'makes sense', such as cultural studies or sociology. These other disciplines rely on the social context to give meaning to the music, rather than discussing the music itself. Musicology can be distinguished by its focus on the music: on discussion of structure and other technical features of music, without necessarily excluding cultural factors that can impact on meaning. Musicology thus includes music history and reception, ethnomusicology, music philosophy and art aesthetics, as well as music theory and analysis. However, as Cook and Dibben observe, there are problems in finding a uniform definition of musicology. In Britain, musicology means the study of and knowledge about all aspects of music, hence musicology includes all aspects of theory as well as history of music composition, performance practice, as well as broad audience and critical reception. Whereas in the USA, musicology is restricted to the study of the history of Western art music, so that music analysis has become a separate strand of music scholarship (Cook and Dibben, 2010:46). Since there is no globally accepted definition of musicology, and both meanings are used in individual pieces of the research literature without clarification, I continue this vague, imprecise usage. Although, I do use 'analysis' more frequently in relation to an investigation of

5-26; Post, O. & D. Huron (2009) 'Western Classical Music in the Minor Mode is Slower (Except in the Romantic Period).' in *Empirical Musicology Review*, Vol. 4, no. 1, pp. 2-10; Tymoczko, D. (2011) *A Geometry of Music: Harmony and Counterpoint in the Extended Common Practice Period*, Oxford University Press.

specific pieces of music based on its technical aspects, the terms ‘musicology’ and ‘music analysis’ are used interchangeably throughout this thesis.

Musicology seems the appropriate discipline within which to discover our current understanding of how the sound of a piece of Western art music which contains no text could ‘make sense’ without significant extra-musical knowledge²⁶ of that music. Musicology is the discipline concerned with the study of the technical aspects of music and its composition. It would seem to be the field within which to find an established transferable process that sets out how the compositional design of specific music suggests an ‘idea’, or, as Weale describes ‘the something to hang onto’ (Weale, 2006:189). However, since we are discussing the sound of the music and the human process of sense-making, it seems sensible to begin with how musicology discusses and uses information arising from the experience of listening to the music.

Fuzzy IDEAS is a formalised method for qualitative study of a personal experience of making sense of an individual piece of music. This requires a transparent yet systematic way of documenting personal insights and technical observations while recognising that this will be incomplete and subjective information. This multi-stage process starts with conscious articulation of the implications of any information known to the listener about the specific music they are going to hear. The next stage is documenting the qualitative listening observations that arise while listening to the music. Then the principles of fuzzy logic set theory are used to convert these qualitative listening observations into fuzzified data. This fuzzified data is then converted into visual form. It is this visual representation of the experience of the music that is used to provide evidence for how technical aspects of this music suggests an idea.

In later stages of the method, the visual representations are considered from two different perspectives. Frequency analysis reveals the amount of variation between individual documented sound events, while time series analysis explicitly focusses on how the technical qualities of the music are shaped into a particular temporal

²⁶ Extra-musical knowledge refers to a listener’s internalised information about the specific music. This might include the composer’s name, the title of the piece, any historical or social context of the specific composition, or the historical performance practice of this genre of music, or information regarding the current presentation of the music, such as who commissioned the music, the performers and their reputation, or the performance venue itself.

design. The final step in *Fuzzy IDEAS* is combining the technical qualities and the time structure revealed in these analytical charts, along with the initial framing ideas, and the immediate insights into the music during real-time listening, to make sense of the music in a more considered way. The synthesis of these three sets of information produces an abductive idea that makes sense of that piece of music.

The primary goal of the visual representations is an accurate yet detailed representation of the multi-dimensional nature of an intangible individual experience of specific music that permits ease of visual analysis. The purpose is to provide a useful mapping of lived experience into symbolic form that is meaningful and transparent, and can be analysed with little computational effort. Using visual representations permits rapid observation of similarities and differences between individual fuzzy events, and the various temporal structures embedded in the qualitative listening observations. This is a clear advantage of using visual displays rather than text-based descriptions. It is much more difficult to use text or numbers to simultaneously represent, and analyse, the multi-dimensional nature of music.

This new method is clearly set out so it can be reproduced and improved by other researchers interested in interpretation of other music or the music I used in my demonstration analyses. Future work includes statistical testing of the utility of the method to establish generalised results across listeners regarding their responses, or perhaps to examine the necessary and sufficient features of specific aural stimuli that result in that music consistently making sense across listeners.

Importantly, this new method of listener-oriented music analysis, with its novel characterisation of music as listening experience, has immediate educational applications. Parts of *Fuzzy IDEAS* are already sufficiently developed to become curriculum materials for classroom music appreciation for school students and adults. Moreover, *Fuzzy IDEAS* provides a systematic method to assist in compositional pedagogy²⁷. Composers could use *Fuzzy IDEAS* to obtain feedback about those features in individual pieces of music that attract the attention of

²⁷ As Chau observes, fuzzy logic has the potential to bring music pedagogy into the 21st century (Chau, 2014:237).

audience members, along with those listeners' responses on how their experience of that music makes sense.

As well as the educational benefits available through using *Fuzzy IDEAS* as it now stands, information gleaned from similar processes can be used to market individual pieces of music more effectively by focussing on listener experience rather than the music. *Fuzzy IDEAS* also has potential for development of digital and social-media mechanism to enhance audience engagement while listening to unfamiliar and unusual music. These mechanisms range from simply providing a means to focus attentive listening, or a means to socialise around avant-garde music including as an interactive method of polling listener responses during concerts²⁸. These technological and marketing innovations could be used to build audiences for avant-garde music, thus providing more support for 21st century Australian composers²⁹.

This thesis sets out the arguments to support these claims in seven chapters and several appendices. The main text contains the rationale for the work and the method in detail, so the rationale for each stage and the work-flow can be examined and applied by other researchers. The appendices are designed to provide background materials that amplify and inform the main thesis text, but are not integral to my argument.

The brief overview of the structure of the thesis presented here is followed by a synopsis of each chapter for the benefit of readers wishing to focus on a particular area of enquiry³⁰. In broad terms, the text begins with the reasons for developing an additional method to analyse avant-garde music, thereby clarifying what the method

²⁸ The potential utility of new social networking methods is apparent when examining new methods for accessing music available in the 21st century, such as internet sites *YouTube.com* (YouTube LLC); and *Apple.com* via *iTunes* (Apple Pty Ltd, 2016), which both distribute music to large and diverse audiences. As will be discussed in more detail in Chapter 1 there is very high participation in providing content to these, and other interactive networking sites, which remains to be exploited.

²⁹ As discussed in more detail in Appendix E. Music in the 21st Century Australian Marketplace, avant-garde music is not widely valued and receives little support from diverse audiences in Australia. As Wilson argues, the current marketing of art music emphasises values of familiarity, permanence and longevity, which means that new music is struggling to gain acceptance (Wilson). A quick survey conducted with data for 2014 reveals that these values are reflected in 21st century mainstream concert programs for Australian audiences. As a result, typical audiences for art music are not exposed to avant-garde music, and seem to be uninterested in contemporary art music as an evolving artform.

³⁰ As readers will have observed, there is a Quick Reference Guide: Glossary of Terms (see pp. xix-xxxi) to explain cross-disciplinary terminology, and my own definitions of some concepts that I use throughout this thesis and the appendices.

needs to achieve. The discussion then moves to explore reasons avant-garde music is generally considered 'difficult'³¹. These reasons suggest that avant-garde music is a good genre for demonstrating how my application of fuzzy logic to visualise the personal experience of listening to music can be usefully applied to make sense of music. The central chapters are concerned with providing the method as a whole³², while readers interested in technical details of how I have applied fuzzy logic principles to create the coding taxonomy can find this information in footnotes to Section 5.1 Converting Qualitative Listening Observations into 'Fuzzified' Data. The final chapters discuss the benefits and shortcomings of the new method as it currently stands, thereby demonstrating the potential for further developments of *Fuzzy IDEAS*, mentioned above.

The main body of the thesis is followed by four Appendices A-D (pp. 279-437) each of which contains one of four analyses each using a different piece of avant-garde art music to demonstrate the possibilities inherent in *Fuzzy IDEAS* as an innovative transferable system for making sense of avant-garde music. The music selected for analysis is outside what Straus identifies as the canonic Modernist repertoire of the 20th century (Straus, 2015:3)³³, and is not representational of all avant-garde music, if that were even possible. However, each one of these four pieces are analysed

³¹ As will be discussed in more detail in Chapter 1, it is difficult to make sense of avant-garde music because it is unconventional and each piece of music needs to be taken on its own terms. Thus, avant-garde music requires active listening rather than habitual response. Further, we need new ways of characterising technical aspects of music to adequately capture the inherent complexity of music, which always existed, but is now highlighted by avant-garde music.

³² An overview of the work-flow in *Fuzzy IDEAS* explored in detail in the central chapters can be found in Table 4.1. The Stages of *Fuzzy IDEAS* in Chapter 4 Table 4.1. The Stages of *Fuzzy IDEAS*. Briefly, the method consists of nine stages:

1. Documenting Pre-Listening Pre-Conceptions
2. Collecting the Qualitative Listening Observations
3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience
4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations
5. Converting the Qualitative Listening Observations into Fuzzified Data
6. Constructing Visual Representations of the Fuzzified Data
7. Analysing the Frequency of Fuzzy Entities in the Visual Representations
8. Analysing the Time Structure of the Visual Representations
9. An Abductive Interpretation: The Idea that Makes Sense of this Experience

³³ Music by Schoenberg, Webern, Berg, Bartok, and Stravinsky are the usual exemplars for analysis of art music that broke with the conventions of tonality (Straus, 2015:3).

using the same method through identical application of fuzzy logic principles and data fuzzification despite the individual nature of each of the four pieces of music³⁴.

These four pieces of avant-garde art music are publicly available³⁵ and include a variety of sound sources, compositional designs, overall durations, nationality and gender of composer. My research does not discuss or focus on any differences these cultural factors may make on the music. The aim was to make an inclusive selection across different types of music by composers with varied cultural backgrounds, although each composer works in the Western art music tradition. Rather, my purpose is to demonstrate how these different pieces of music can each make sense, given the title and any other background knowledge that the listener brings to their listening, in conjunction with the technical details of the music and personal responses noted during listening. These four demonstration analyses are followed by another set of Appendices, E-J (pp. 439-513). These additional appendices simply provide background knowledge that informs or amplifies the main text. The appendices make this information available should there be a desire for more detail on various technical aspects of my research, however, the body of the thesis contains the core of my research and supporting arguments.

Quick Reference Guide: Glossary of Terms. *Fuzzy IDEAS* incorporates concepts from computer science developments of artificial intelligence, with its discipline-specific terminology and ways of thinking about data, machines and humanity. *Fuzzy IDEAS* remains firmly grounded within musicological discourse about music

³⁴ The utility of fuzzy logic to produce a generic algorithm which can be applied consistently across varied systems each using the same underlying communication protocol has been demonstrated by Kreković, Pošćić, and Petrinović, (2016).

³⁵ 'Publicly available' in relation to avant-garde music is challenging to define. All the music used in the demonstration analyses can theoretically be purchased by the general public as the music is available on recordings by reputable non-commercial institutions. However, locating the recordings may be somewhat difficult in practice, because many recordings are sold in boutique locations for a limited time. This may be due to small public interest in avant-garde music, or simply reflects the oligopolistic nature of the commercial recording industry driven by the profit motive rather than an interest in developing art forms.

Anecdotally, in 2007, I sought to buy a CD of a relatively well-known and performed piece of 20th century music: Messiaen's (1942) 'Quatuor pour la fin du temps' (Quartet for the End of Time). As Griffiths documents this music was composed and premiered in a Nazi prison camp during WWII, then widely played in the following 60 years (Griffiths). Even though this music is relatively well-known compared to the music analysed in this thesis, a physical search in music stores in Melbourne, Australia, revealed many recordings of music by Mozart, Beethoven and Chopin, but no recordings of this particular music. Although an internet search at the time showed recordings available for purchase via only three websites, clearly this music is currently regarded a niche product.

analysis and theory of music, so much of the technical discussion about music uses the terminology of that discipline. The terminology within the thesis is frequently discipline-specific as a simple way of moving the argument along without getting caught in explanatory details. This quick reference guide aims to unravel some of the mysteries resulting from using everyday words in discipline-specific contexts.

Chapter 1. The Importance of Making Sense of Avant-Garde Music. This chapter explores reasons that avant-garde music can be considered ‘difficult’, which may contribute to its low value in the 21st century music market. Further, the apparently simple problem of making sense of an individual piece of avant-garde music results from the inherent nature of music as an intangible, time-based artform, which can only be experienced individually. I then make the argument that a method that explicitly incorporates the subjectivity of response and values a personal experience of listening could be a useful way to make sense of avant-garde music.

Chapter 2. Existing Approaches to Listening as a Sense-Making Activity. This chapter explores three major approaches to making sense of music: musicology, which looks to the music; psychology, which looks to the listeners; and music producers who look to information. There is emphasis on how each approach explicitly addresses music as an unfolding process in real time and the approach to subjective idiosyncratic personal responses to the sound of the music as it unfolds.

Chapter 3. Fuzzy Logic and Music. This chapter sets out the reasons fuzzy logic is a useful tool for investigating avant-garde music by using a listener’s personal responses. Chapter 3 continues with a review of existing research into a range of music problems using fuzzy logic for analysis either by machines or by humans. This literature is scattered among journals in computer science and engineering, rarely in music. Collating this literature into a coherent body of work is a particular contribution of this thesis. The review shows that no existing research involves the practical application of fuzzy logic to make sense of music from a listener’s perspective, although some recent developments foreshadow my innovative method as written up in this thesis.

Chapter 4. *Fuzzy IDEAS*: Listener-Oriented Music Analysis. This chapter provides an overview of the working methods of *Fuzzy IDEAS*. The chapter contains a discussion of the need for an auto-ethnographic approach to listening and analysis, as listening to any type of music is an aural encounter with sound in real time that can only be experienced individually and subjectively. The chapter continues by explaining the first four stages of the method that are concerned with collecting the qualitative listening observations, examining this experience of listening, and the initial abductive hypotheses, so the method can be applied systematically to different pieces of music and replicated by other researchers.

Chapter 5. *Fuzzy IDEAS*: Applying Fuzzy Logic to Analyse Avant-Garde Music. This chapter explains why visual representations are valuable forms of documentation of the experience of music and addresses the system of mapping of the fuzzified data into visual representations of the listening experience. This chapter then continues the full explanation of the method to describe how the visual representations are constructed and used to make sense of the music. It is in this part of the method that the innovative practical application of fuzzy logic occurs. Fuzzy categories for the coding taxonomy are derived from two sources, one predetermined and the other context-dependent. The predetermined attributes are derived from the acoustic attributes of sound as a physical object, while there are additional categories for any other technical aspects of the sound of the music emphasised by the individual listener in their qualitative listening observations.

Chapter 6. Discussion of Mechanics of *Fuzzy IDEAS*. This chapter considers the unique approach to understanding music and the contribution to knowledge made by *Fuzzy IDEAS*. The chapter includes a discussion of my practical application of fuzzy logic principles in terms of fuzzy logic theory. I have used *Fuzzy IDEAS* to collect two types of data on its utility. Four demonstration analyses and a small evaluation are used to evaluate the method. The evaluation establishes proof of concept that *Fuzzy IDEAS* is transferable among pieces of music and listeners as it is possible to make sense of the music based on their qualitative listening observations. Therefore, using modern tools of digital technology, particularly fuzzy logic and detailed visual representations, it is now possible to study compositional design through a lived experience of listening.

Chapter 7. The Future of *Fuzzy IDEAS*. *Fuzzy IDEAS* is already prepared for implementation in music appreciation courses and for application within compositional pedagogy. The new method is ripe with possibilities for extensions into new modes of data capture on listener responses. With further development, *Fuzzy IDEAS* has potential to encourage audience engagement with avant-garde music both in terms of attending concerts and with the music while listening. These potential developments add to the value of the research reported in this thesis.

In summary, my research into the application of fuzzy logic principles to develop a visual representation of a personal listening experience has resulted in a transportable systematic method of analysing music, which openly acknowledges subjectivity and explicitly incorporates the time domain. Having demonstrated that this method works to make sense of avant-garde music while allowing insight into technical aspects of the music that help make sense of it, I suggest that this new method has potential for making sense of music composed using any materials, techniques and forms.

Cited References

Appendices A-D. Demonstration Examples of *Fuzzy IDEAS*. These studies demonstrate the application of *Fuzzy IDEAS* to make sense of four different pieces of avant-garde art music, using only the information available from the personal experience of one listener. Yet, as a group, these studies demonstrate that the method can be consistent across different pieces of music.

- **Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984).** Germany, Solo Piano. Duration: 13'14".
- **Appendix B. *Fuzzy IDEAS* applied to *Women in Transit* (Hope, 2004).** Australia, Digitised Found Sounds. Duration: 10'04".
- **Appendix C. *Fuzzy IDEAS* applied to *Durations II* (Feldman, 1960).** USA, Cello and Piano. Duration: 7'10".
- **Appendix D. *Fuzzy IDEAS* applied to *Concert for Piano and Orchestra* (Cage, 1957-58).** USA, Piano and Orchestra. Duration: 27'44".

Appendix E. Avant-garde Music in the 21st Century Australian Marketplace.

This appendix gives a historical overview of the economics of art music composition, and the current status of the art music ‘industry’ in 21st century Australia. This shows that the music of contemporary composers is less valued in modern times than in previous eras.

Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications.

This appendix outlines the theoretical aspects of fuzzy logic that inform the design principles incorporated into *Fuzzy IDEAS*. This appendix distils the important aspects of fuzzy logic theory relevant to music. Fuzzy logic theory is available in much greater complexity in computer science and management decision-making literature, should the reader choose to seek more information on the theoretical background of specific principles.

Appendix G. Timeline of Music Research using Fuzzy Logic. This appendix shows the year by year publications by subject area and research topic. These research publications are organised chronologically from the first outline of fuzzy logic to the analysis of melodic phrases in 1992, to the latest peer reviewed publication, where fuzzy logic is being used to assist classical guitar students practice more effectively. This demonstrates how fuzzy logic is still arriving on the music scene and the individual nature of much of this work.

Appendix H. Evaluation Procedural Documents. This appendix includes the Listening Test Questionnaire and other information provided to participants.

Appendix I. Evaluation Test Results. This appendix presents a summary of the results of applying *Fuzzy IDEAS* to make sense of *Scharlachrote Buchstaben* based on qualitative listening observations collected from three other listeners.

Appendix J. Academic and Creative Research Publications during PhD Candidature. This appendix provides details of peer reviewed publications and general presentations of academic work, as well as music composed and performed during my candidature as a doctoral scholar.

Chapter 1. The Importance of Making Sense of Avant-Garde Music

This chapter is concerned with philosophical and definitional considerations encountered in investigating the apparently simple problem of making sense of a lived experience of an individual piece of music. The challenges result from the nature of music as an intangible, time-based art form which can only be experienced by a single set of ears belonging to a single brain embodied in a single human form, even within a communal setting such as a concert hall¹. Further, the composer designs the title and specific technical aspects of a piece of music, including how the sound is to unfold, knowing these will impact on how that music makes sense to each listener regardless of their personal history.

Paradoxically, subjective responses to music are inevitable, although as will be discussed in Chapter 2 Section 2.2 (see pp. 67-81), analytical discourse about music uses a variety of tactics in the search for objective ‘truth’. It is important to bring subjectivity out into the open, because suppressing subjective responses has had some wide-ranging ramifications for music discourse and the appreciation of avant-garde music². Avant-garde music is important because it is music unique to our time. Avant-garde music addresses contemporary technology, presentation practices and, sometimes, cultural concerns, along with new approaches to formal structure and other aspects of compositional design. This chapter explores the challenges presented to listeners by avant-garde music, and the need to recognise and embrace the importance of, rather than ignore, subjective responses while listening.

Some avant-garde composers have embraced sound, i.e. ‘timbre’, rather than harmony, as the primary material for their work. This divergence from centuries of

¹ For some reason, the necessary occurrence of subjective individual experience has become a uniquely unresolvable problem of music analysis. This seems odd, since 21st century psychologists and marketing experts are well aware that even though we necessarily experience everything individually, there are commonalities of experience which can be, and are, exploited for personal wellbeing or commercial gain or both. Without implying that composers wish to exploit listeners, it seems reasonable to think that composers work with a similar concept when producing music to communicate ideas to an audience.

² ...or should I say, the deprecation of avant-garde music as ‘just noise’.

music described as constructed only from melody and associated harmony, voice leading and linear harmonic rhythm³, has raised fundamental questions about what defines ‘music’, in particular, about how music can be distinguished from any other stream of sound.

Streams of sound include bird song and the babbling of water running over stones, as well as those distinctive sound streams arising from noise⁴, music and speech. Some composers, such as Biles, suggest that there are only two defining characteristics of music: that it is aural and it is temporal, and that it is really the listener who determines whether bird song, or other ambient sounds of daily life are as much music as conventional instrumental music (Biles, 2007:29). This definition suggests that each individual listener determines whether a stream of sounds makes sense as ‘music’ or as ‘noise’.

A listener may distinguish ‘music’ from ‘noise’ by recognising an intention by a ‘composer’ to use sound as the medium to communicate an idea external to the sounds themselves. Clearly, some sounds are ‘performative’. Using an example from speech, onomatopoeic words such as ‘whisper’ have a sound similar to the act being described. In music, recorded or imitated natural sounds may be regarded as similarly onomatopoeic and are used in music for literal effects, such as the cannons in Tchaikovsky’s *1812 Overture*. However, the composer’s idea in art music is often only indirectly related to the specific quality of the sounds because the sounds as a group do not directly reproduce or perform the idea.

‘Music’ is more complex than ‘sound’ as music is constituted from one or more physical sound objects occurring over a period of time, yet perceived by a listener as related to each other⁵. Reich also argues that sound and music are not identical in

³ For instance, Straus’ survey of Forte’s analyses of canonic repertoires ranging from Classical to 20th Century Modernist, asserts that Forte relies on a concept of music in which these building blocks are the only fundamental materials of music (Straus, 2015:4).

⁴ Noise not only exists as a value judgement, but also ‘noise’ exists in its own right as a sound-type. Examples of noise sound types are everywhere, including those produced on demand by scientists for experimental reasons, or the sound emanating from engines running, or the naturally occurring sound of surf crashing on the beach. Each method produces a blanket of ‘noise’ that effectively masks other sounds. ‘Noise’ does not have to be loud to be effective.

⁵ However, as Darhlhaus recognises, by the mid-20th century there were no longer predetermined principles about what gives one stream of sound more value as music than another, because the “...classical dogmatism, which dominated nineteenth-century aesthetic and pedagogic musical thought” had disintegrated (Darlhaus, 1983:viii).

his evaluation that “...Cage's primary idea is that any sound is music, yet it is obvious (even to children) that all sounds are not music” (Reich, 1973:72). This statement seems self-evidently true, that there is a distinction between sound and music. Yet listeners rarely make the distinction between sound and music. Rather, as Vella explains, individuals make their own distinctions between music and noise (Vella, 2000:38). Distinguishing music from noise is perhaps complicated by the emphasis on ‘noise’ as a sound type in some avant-garde music. Vella argues that ‘noise’ as a sound type has always been an essential component of music through the use of percussion; however, in the 20th century the Italian Futurists and composers of *musique concrète* explicitly made noise an integral part of their sonic palettes (Vella, 2000:20-21). This may add to the challenge of distinguishing music from noise when listening to music which is unfamiliar in timbre, and in presentation methods⁶.

The 20th century music revolution and simultaneous technological developments have resulted in sound objects becoming a primary material of music. Chadabe states that beginning in the early 20th century, a number of composers working with conventional acoustic instruments promoted the viewpoint that any sound could go together with any other and this would constitute music (Chadabe, 1997:22). As the century unfolded, composers such as Cage extended the concept of music to include all sounds as musical events even those that are incidental to the performance and occur despite not having been specified by the composer, nor performer. This allows theorists, such as Biles, to suggest that bird song and running water could be music (Biles, 2007:33).

Foreshadowed in the early 20th century by the Italian Futurists’ use of real machines to produce new sounds in music, later use of electronics and computers in the creation of music has opened new possibilities for using synthetic and sampled real sounds in music composition. These electrical technologies led to the development of acousmatic music, where the music is composed using only electrically produced

⁶ Conventional music is usually performed in a particular arrangement of performer up front on stage and audience seated *en masse* below. Avant-garde music may not be performed ‘live’ by human performers in real time, so the actual music is presented in different formats ranging from loudspeaker arrangements in immersive environments, to single-user headphones receiving streaming audio over the internet, to a solo machine or a human performing outside the concert hall. Consequently, the term ‘presentation’ is used throughout this thesis to generalise the concept of performance to include all genres of music.

sounds without acoustic instruments. Then in concert-style presentations, the acousmatic music is re-produced through various electrical playback systems. As Vella explains, these new technologies provide new opportunities for composers to blur the distinction between sound and music (Vella, 2000:39). The 20th century saw the development of electronic equipment that can synthesise sound rather than simply record and reproduce existing sounds. In particular, as Jehan observes, composers primarily concerned with applying these synthesis techniques make very little distinction between sound and music (Jehan, 2005:29-30). This could arise because, according to McNeill and Frieberger, humans have an inherent tendency to use language to simplify things (McNeill and Freiberger, 1993:68). This natural tendency to simplify complex concepts is not the only factor that contributes to muddling of distinctions between sound and music.

Sound and music are both multi-dimensional because they are dynamic mediums of communication. Although a physical sound object has similar qualities to music, music is different from sound for a variety of reasons. A sound refers, or points, to a discrete event. Music is more individuated, intricate and versatile; it requires imaginative composition⁷ and thus can suggest more complex ideas than sound. However, it is inherent in the nature of sound alone to produce responses in the listener, as sounds always signify some object, some activity, some person or any combination of the three. Sounds such as bird song, or rain on a tin roof, might seem like music because they are of long duration and incorporate some elements of music such as melodic motifs or rhythms (but is an ambulance siren, with its characteristic changes in pitch over time, music?). Some sounds might seem like music because they are perceived as 'beautiful' (what if the bird song is a cockatoo squawking?), or if the sound has positive meaning to the listener (does laughter always represent happiness?).

Just as the experience of composing to express an idea through sound resides entirely within the composer, and the physical sound objects in the music provide guidance on ideas in the music, the experience of making sense of the music resides entirely within the listener's brain and body. Further, if a stream of sound is

⁷ For instance, Juslin and Laukka, psychologists studying the perception of music acknowledge that compositional features such as texture and chord types can be significant factors in communicating emotions through music (Juslin and Laukka, 2003:774).

conceived as music only when it is perceived to contain an idea that makes sense of what that listener is hearing, then determining what is music is thus necessarily an auto-ethnographic experience. Various streams of sounds exist and it is the listener who investigates these sounds to see how they might make sense, including making sense as 'noise', or being identified as bird song rather than music. Therefore, analysing a personal listening experience is one way of investigating how the stream of sound that constitutes the music makes sense.

While it may be true that each listener is the final arbiter between 'music' and 'noise' depending on their personal tastes; in this thesis, the key distinction between 'sound' and 'music' is determined by the existence of compositional intent to communicate through the medium of sound. The composer is seen as an active agent in manipulating sounds to produce a particular design. Because of this intent, the resulting stream of sound can be called 'music'. Even though, the term 'expression' in music discourse is practically meaningless through being overused and ill-defined, music, as I have defined it, must necessarily be expressive to make sense. Music only exists when a listener perceives a composer is 'expressing' an idea through the medium of sound⁸. As explained in Section 1.3, The Challenges of Making Sense of Avant-Garde Music (see pp. 47-58) there is a divergence between conventional ideas about the experience of music and the challenges of new music by today's cutting edge composers.

1.1 Understanding Music as a Mode of Communication

In their new approaches to music, avant-garde composers tend to emphasise alternative ideas, not simply expression of emotion or generation of 'feeling' or 'mood'. Summarising the range of ideas provides a perfect illustration of the fuzziness of classifying music. Individual composers and commentators provide vague descriptions or use general terms to describe their music, providing no real pointer to the specific ideas that inform the music under consideration. The final problem is that there may be more than one idea informing the music of individual composers. For example, Burt's compositional ideas cross several categories

⁸ Like communication in other human endeavours, all ideas not necessarily expressed equally well.

because his descriptions start from the general and work towards the specific as he describes in presentations about his music (Burt, 2009). However, with a broad-brush approach, several meta-ideas can be sufficiently delineated based on commentaries from musicologists as well as composers.

For example, some contemporary composers see their role as social commentators through composing music, as Brun argues, “...directed against the state of affairs, be critical, rebellious and negative” (Brun, 2004:79). Indeed, Indeed, Eno suggests composers do focus on social issues by using “...metaphors about how the world works, how things organise themselves, how things are controlled, what possibilities there are...we don't get rid of old metaphors, we expand them to include more...through the metaphors that dominate our thinking” (Eno, 1996). Eno is not alone in this approach. For instance, Cage was looking for “...an anarchistic society of sounds” (cited in Popoff, 2010:77), while Reich's method “...is to take several looks at [historical actions] from different points of view” (Hillier, 2002:6). However, ideas external to a piece of music are not confined to the interpretation of avant-garde music.

A range of suggestions has been made for the meta-ideas behind purely instrumental music composed on tonal principles. Several musicologists view tonal music as a narrative in which the individual is subjected to group norms. For instance, McClary identifies tonal music as “a story of potentially antagonistic forces [two theme groups in different keys] ultimately moving together to achieve a single long range goal [the tonal centre]. This narrative reflects the social stratification of the Industrial Revolution and the interests of the ruling classes” (McClary, 2000:80-81). Further, Attali argues, tonal music represents the image of ultimate social cohesion, adopted to persuade people that there is harmony in orderliness (Attali, 1985:46). Similarly, Garofalo identifies Hitler's repeated use of Wagner's music to glorify heroic struggle and war and thus to signify that both were desirable (Garofalo, 2010:736). Further, Seymour argues that Britten's music, especially his operas, refers to the personal psychological impact of contemporary social conventions on homosexual visibility (Seymour, 2004). Clearly, musicologists are aware that music has the potential to make statements about social conditions.

In contrast to political expositions, some composers work with sensory experience, each in their own way. For instance, Burt has spoken about auditory pleasure in the

quality of the sound simply for its own sake (Non-Verbal Intelligence, Burt, 2009), by using techniques such as “...amateur performance, incompetence, found objects, and the like in my composing and performing” (Artwonk, Burt, 2010). By contrast, LaMonte Young has carefully designed a slowly unfolding piece of music which also works with sensory experience⁹. Brown suggests that Young’s music “...may draw the audience attention to sonic details which are usually ignored, such as small pauses during the reversing of the bowing in sustained drones” (Brown, 2010:186) or perhaps, as Hillier suggests, the music is designed to alter perception of time (Hillier, 2002:14). Reich also uses a particularly strict, formalised compositional technique for determining the unfolding relationships between sounds, but realises that “Listening to an extremely gradual musical process opens my ears to ...the details of the sound...occurring for their own acoustic reasons” (Reich, 1968:35). Eno also uses a set of predetermined algorithmic rules that combine to generate the actual sound events in order to perceive the changing relationships occurring between the sounds as the music unfolds (Eno, 1996). This variety of compositional approaches and sound sources shows that very different music can be concerned with communicating very similar concerns regarding the sensory experience of the minutiae of sounds.

An alternative, almost opposing idea is to investigate how music produced by highly structured processes might be re-composed to produce music in which every note is completely intentional. Boulez asserts this is his idea for *Structures*: to see how borrowed music, which according to Boulez was initially designed by Messiaen as “...mechanical wheels-within-wheels tending almost to random “ (Boulez in Deliege, 1976:56-57) could be made completely intentional. Interestingly, Boulez acknowledges that although *Structures* “...introduces personal invention as it goes along, the pieces are not printed in chronological order so this is not clear to the listener” (Boulez in Deliege, 1976:55). Boulez, however, is not clear whether this lack of transparency was intentional or simply that he is aware that the impact of music on listeners is different from compositional methods.

⁹ These different interpretations of Young’s String Trio provide a good example of how the focus of listening affects the way different listeners make sense of the same music. However, both interpretations still emphasise the role of the composer in designing the music on the basis of particular ideas about sensory experience.

Some other avant-garde composers do, however, consciously use impersonal compositional processes to remove individual existential self-references from their music. This is a critical response to the preoccupation with the inner self by the Romantic composers¹⁰. For instance, Reich says that his “...work is more about materials and processes than about psychology” (Reich, 2002:33) because “focusing on the musical process makes possible that shift of attention away from *he* and *she* and *you* and *me* outward toward *it*” (Reich, 1968:36). However, as Cope explains, their choice of methods and materials still reveals their individual personal philosophy and attitudes (Cope, 2008:304). Nonetheless, Reich maintains that the music is impersonal even though the composer has made all the input and process method decisions, because all the outcomes of the predetermined processes are performed (Reich, 1968:35).

Some avant-garde music is composed to explore new technologies for sound production. The ability of machines to produce sound and the advent of technology to control it led to the development of *musique concrète* or tape [now computer] music. In its early days, Chadabe observes, tape music composers were exploring the possibilities inherent in the new technologies, rather than embodying traditional values of beauty in music. As a result, the medium of production and presentation, and the product, the sound of the music, were identified as one and the same (Chadabe, 1997:ix-x). Even though computer music is still relatively ‘new’ compared with conventional acoustic music, as time passes the music becomes less about electronics and more about other ideas (Vella, 2000:208). By the late 20th century, digital technology had become simply another tool for composers that does not necessarily produce a particular style of music (Chadabe, 1997:x-xi). Although avant-garde music is not confined to computer music, it can be challenging for any new compositional techniques for any means of sound production to be recognised as an ‘idea’ informing music.

Transcendence is the paradigmatic positive listening response to Western art music. Juslin and Sloboda (2001:5) argue that this is the result of 19th century philosophical approaches to music which saw that the primary way of making sense of abstract

¹⁰ At the end of the 19th century, German intellectuals declared that individualistic expression of the inner self was legitimately the primary concern in a composer’s music (McClary, 2000:111). This idea was adopted by Romantic composers in other countries (Griffiths, 1983:113).

instrumental music was through the intellectual understanding of the history and form of a musical work. As a result, emotional response is restricted to transcendent and spiritual aspects rather than full-blooded emotion. Yet, as Sloboda and Juslin observe, “one of the most prevalent cultural discourses about music concerns its emotional power. This discourse surrounds us from our earliest years” (Sloboda and Juslin, 2001:98). Juslin and Sloboda argue that the ‘classical concert culture’ characterised by attitudes which give primacy to transcendence is assumed and perpetuated throughout musicological scholarship, with the result that there is no academically accepted means of framing and understanding emotion (Juslin and Sloboda, 2001:5). The result is a variety of approaches to investigating the relationship between music and emotion.

Music can provoke emotional reactions and suggest inner experiences. Sloboda and Juslin argue there are two type of emotions in music: ‘iconic’ and ‘associative’. ‘Associative’ reactions occur when the music triggers emotions or memories of emotionally laden events. Hearing the same specific piece of music triggers these reactions, rather than the responses being directly related to the intrinsic features of music itself (Sloboda and Juslin, 2001:95). Juslin and Sloboda note shared cultural experiences can trigger similar memories, and hence the same emotional response, for large numbers of people (Sloboda and Juslin, 2001:94-95). ‘Iconic’ reactions are based on recognition that there are resemblances between the technical attributes of the music and an emotional state (Sloboda and Juslin, 2001:95). Sloboda and Juslin (2001:95) provide the example that loud and fast music suggests a high energy emotion such as excitement, but do not elaborate whether this relationship is made by recognition of symbolic gestures in the music, or is self-awareness of bodily response to the sound of the music that is felt as excitement.

We listen within the context of 21st century Western cultural experience. For example, I find it difficult to hear a Brahms symphony without thinking of film music because much film music is based on the symphonic tradition¹¹ in which Brahms

¹¹ For instance John Williams’ film music, such as the theme over the opening titles for the first Star Wars movie in 1977, written in “...Romantic symphonic language” (John Williams in Grieving, 2015) or the music of Eric Korngold in Hollywood movies of 1930s and 1940s (Mervyn Cooke).

was a significant influence¹². Film music as a genre, with all its extra-musical implications of imagery, characterisation and suspense could not have influenced Brahms' contemporary audience as film did not exist when Brahms was composing his music. It is, however, possible that his contemporary audiences spontaneously read these ideas into the music, which is why his music was adopted as a good model for film scores.

Music discourse repeatedly refers to 'expression', even though even here there are differing views on the capacity of music to be expressive. For instance, Stravinsky asserts that music cannot intrinsically express anything, whether it be moods, emotions, or nature, and that any expression perceived in music is only illusory, the result of listening convention, not the music itself (Stravinsky, 1975:53). Perhaps this perspective arises, as Seymour explains, because "...the non-referential nature of music renders it impossible to determine the precise or 'literal' meaning of a musical event" (Seymour, 2004:6). However, Scholes concludes that unless music directly imitates the sounds of nature, then the intangible and abstract, the non-referential nature of instrumental music, means that music is necessarily an expressionist artform (Scholes, 1970:340). He defines 'expressionism' as a genre of art that records the "inner experiences" of the artist in response to a particular object (Scholes, 1970:339). Harris defines inner experiences to include "...thoughts, memories, emotions, urges, mental images, and physical sensations" (Harris, 2007:24). Clearly, Scholes does not think that naturally occurring sound objects have the capacity to be evocative or to suggest inner experiences, but both sound and music can be suggestive.

Clearly, there are broad differences in the sound and presentation of various types of Western art music. Yet 'music' is the common term used to describe diverse genres, including avant-garde 'music' and computer 'music'. Focussing on commonalities between different genres, rather than the differences, provides general insights into what constitutes music as a lived experience. The definition of music as "organised sound" (Varese and Wen-chung, 1966:18) lacks explicit references to the purpose of the organising, or even who is doing the organising and

¹² Brahms' music is an interesting example, as he was, as identified in the Concise Oxford Dictionary of Music, an outspoken advocate for 'absolute music' in the 19th century debates about the value of 'program music' (Kennedy and Kennedy, 2007:97).

what that might involve. However, as discussed previously, there are two principles of music: first, ideas are fundamental to the existence of all music. Second, that music as lived experience is a dynamic process unfolding over time.

Tagg observes there is an absence of formal teaching regarding distinctions between sound types in music, as well as distinguishing between the culturally specific connotations and social functions associated with these different sound types (Tagg, 2012:120). At an even more detailed level, there is no formal teaching about the finer distinctions, such as how particular music describes a specific kind of love or ethnicity. Tagg points out that the consequences of this omission are that “...compared to analytical metalanguages used to address questions of structure [and resulting affect] in visual and literary arts...” (Tagg, 2012:121) music discourse is quite restricted in user-oriented terms. Therefore, musicology has not been able to properly address how particular combinations of sounds can communicate specific meanings to listeners. This is exacerbated by the tendency of musicologists to see the score as the music. However, the score is an archival document written in music symbols representing several technical attributes of individual notes throughout a piece of music. The score and the sound of the music as it unfolds in performance may not be the same thing.

The word ‘expression’ is used ubiquitously in relation to music. Typically, theoretical texts on technical aspects of music simply bypass the entire issue of how ‘expression’ can be composed into music, following an obligatory acknowledgement of its importance. For instance, Hansen suggests that “...music is, or should be, a means of communicating those feelings which seek expression with simplicity, clarity and consistency” (Hanson, 1960:vii-viii) while “...composers are searching for a new expressive vocabulary” (Hanson, 1960:vii). This acknowledgement of expression must presume some common understanding because, despite explicitly stating his goal is to provide a useful vocabulary for composers, as well as explaining how to achieve particular qualities of sound (Hanson, 1960:viii-ix), there is no detailed explanation of techniques for introducing ‘expression’, among the extensive theoretical explorations that constitutes the book. Indeed, the contents of the book clearly imply that technical features of music need, and can be given, detailed consideration and explanation. Hanson’s prolonged explanation of pitch structures shows that common understanding of even relatively measurable elements do not

exist. Hence, it is unlikely that there is any common understanding or explanation of more intangible concepts such as 'expression'.

Difficulties in articulating the concept of expression in an intangible, abstract art form, such as music without text, arise because of the paradoxical use of the word in relation to performance and in music criticism. Baker points out that "in the simplest sense expression is applied to elements of a performance that depend on personal response and vary between interpretation...[yet] it is not clear how this use of the term "expression" relates to the concept that occurs in music criticism (such as when a work is said to express some emotion, outlook, or idea)" (Baker, n.d.). The major reason for 'expression' being used with apparently different meanings in each context of performance or critical appraisal arises from the problematic relationship that musicology has with music being an intangible aural experience. This unwillingness contributes to the difficulties in consistently locating 'expression' in performance or composition.

Distinguishing who is responsible for the music being 'expressive' has contributed to, and been a result of, an unwillingness by musicologists to confront the reality that music is necessarily an aural subjective experience that therefore requires performance for its existence but begins with the composer's ideas. Both performer and composer contribute to the 'expressiveness' of an individual piece of music. Performers must, by their very nature as intermediaries, impact on the presentation of the ideas through their influence on the sound of the music. The difficulty for music discourse lies in finding a concrete way to describe the consequences and impacts of the auality of music, both of which are intangible and evanescent. Music is what composers design and performers play. The split between performance and composition reflects difficulties encountered in working with the reality that music is an intangible aural experience that can only be perceived by individual listeners.

Performance is required to bring all music into existence, whether by human performers or by machines. This contributes to problems in directly addressing the affective properties of music. Although all music requires performance for its existence, some music begins with the composer's ideas notated in score form. Treitler suggests that reading the score is an activity equivalent to listening in real time (Treitler, 2011:72). Not only does this favour those with excellent audiation

skills, such as trained musicians and computer programmers, but it also requires excellent score-reading skills¹³. Although Treitler acknowledges that music is about hearing, not seeing (Treitler, 2011:72), his notion of score-reading as performance confirms Robert Walser's conclusion that musicologists use 'music' simply as "...shorthand for the scores of American and European modernist composers..." (Walser, 2003:27 note 16). Audiences hear music, but they will never see it.

Performance is required to transduce¹⁴ the composer's ideas, whether sketched, precisely notated, or programmed into computer code, into the aural experience we know as music. In some cases, the listener is presented with music quite different from the score or internalised audiation, as Treitler demonstrates that some highly regarded professional performers deliberately alter the music significantly in concert performance (Treitler, 2011:86-87). This performance, the aural experience of the embellished score, is the music that listeners encounter with ears and mind as we make sense of the actual stream of sound as it unfolds over time. As will be discussed later in Section 1.3 a (see pp. 54-57 below), there are a number of problems in using the notion of 'expression'; however, these are side-stepped by the concept of 'sense-making'. Using 'sense-making' to describe the process of understanding how the sound of a piece of music conveys an idea is a more pragmatic way of investigating the link between compositional technicalities and the aural impact of the music.

¹³ Treitler's definition, even though specified in the 21st century, still reduces music to old genres. He ignores the decades over which composers have and do use computer programs, which are not score-based, for making music. Imagining the sound of the music produced by most music programming software is at least as much a specialist art as score reading. Indeed, some popular computer music languages such as Puredata (Pd) or Max 5 are not even designed to explicitly show the time dimension. By default, they do not display the sequence of sound events as they are to occur. Although these programs run on clock ticks as do all computer programs, the time counters work away in the background controlling the instantiation of individual sound events. What the program code actually shows are the settings and the interrelationships between multiple attributes in order to produce individual sound types, waiting to be activated by the background clock. By comparison, the score at least gives a symbolic representation of the temporal dimension of music. The score shows the relative time sequence, as well as the relative pitch and duration in representational symbols for each individual event, from beginning to end of the music, but does not precisely define the aural qualities of each sound event to the same degree as music software.

¹⁴ Using a metaphor built on terminology from audio engineering where, as Nisbett defines, 'transduce' means to convert audio information from one medium to another (Nisbett, 1993:191).

1.2 Making Sense of 'Sense-Making'

The only question left to a listener is to ask how the music might make sense. As Budd spells out in relation to emotional content, "... the emotion the composer or performer once felt...is not a feature of what the listener hears..." (Budd, 1985:18). Therefore, the listener might consider what plausible idea, including the possibility of emotional utterances, might inform this particular stream of sounds and enable this stream of sounds to make sense.

Avant-garde music, almost by definition, rarely creates an 'easy-listening' environment that provides listeners with the conventional 'blissing out' response. Instead, avant-garde music requires listeners to actively engage with and make sense of the music, thereby deciding that what they are experiencing is valuable in some way. As Nettl identifies most people would agree that Haydn's compositional work is music, but not all would include the work of John Cage, or electro-acoustic compositions (Nettl, n.d.). In some ways, this divergence of perceptions simply echoes the 19th century debates about the relative value of program music and absolute music. However, unlike the contemporary divergence on what might be worth valuing as music, advocates from both sides of the 19th century debate recognised that it was all music, the debate confined to the relative values and merits of each type of music. A large part of making sense of avant-garde music is to actively engage with the sound of the music, to decide that the unusual and unfamiliar sounds and designs that listeners are hearing do make sense as music, not meaningless noise.

Making sense of music is not the same as ascertaining aesthetic value. Aesthetics only became a significant concern of the philosophy of music at the end of the 19th century after serious music entered the realm of entertainment. As discussed in Appendix E Avant-garde Music in the 21st Century Australian Marketplace (see p. 439) the rise of capitalism brought composition and performance into the marketplace (McClary, 2000:114). McClary argues that as a consequence the critical approach to art music changed to preserve the special place of this music. Aesthetic appreciation meant a new way of listening to art music, to find its 'true meaning' in its structure, rather than simple enjoyment of surface details (McClary, 2000:114). Further, as Juslin and Sloboda explain, "appreciation of music" has come to mean

having an intellectual understanding of the history and form of a musical work, rather than an articulated emotional response to the music experience (Juslin and Sloboda, 2001:5). However important aesthetic values have become for the critical reception of music, several researchers point out that they are not a helpful way to understand and make sense of unfamiliar music (Habermas, 1980:11-12; Halpern, 1992:45). 'Aesthetics' is concerned with gauging the value of a piece of music based on the assessed importance of the perceived idea, and the means and skill by which that idea is expressed. By comparison, sense-making is concerned with identifying an idea arising from the sound of the music without judgement.

'Sense-making' is a better term to use than 'meaning' to describe the cognitive activity associated with listening to music. Discerning meaning in music is difficult because music is a non-verbal form of communication. Sense-making refers to a mental, sometimes a conscious intellectual process and sometimes an 'ah-ha' moment of insightful knowing; it also refers to the impact of felt sensation, physical and/or emotional. As Clarke explains, those musicologists who discuss meaning as if it were a shared and self-evident property of the music are engaging in "...armchair hermeneutics that ignores unpredictable practical reality" (Clarke, 2005:123). Meaning is more literal mapping from one domain to another. Use of the word 'meaning' in relation to music implies that there are specific qualities which can be embedded in any music, which can then be decoded accurately as pointing to a specific object.

It is possible that music is a precise carrier of meaning, the problem being that music is difficult to describe verbally. Therefore, as Tagg asserts, the problem of identifying a specific meaning in music arises during the process of transducing the meaning when converting from one medium, music, to another, words (Tagg, 2012:193). Further, as Tagg observes, "Talking and writing about music as if it meant something other than itself is very difficult" (Tagg, 2012:195). Tagg's solution is to develop a theory of musical semantics to understand the meaning of music in general terms (Tagg, 2012:121). Tagg argues that the way music indicates meaning relies on a shared understanding between sender and listener of the implications of the particular qualities of the music and by the causal, spatial, temporal or cultural proximity of particular qualities in the music to the object to

which they are referring (Tagg, 2012:193). However, developing a shared sign system between composer and listener is difficult to achieve without words.

Spoken language provides the most obvious example of the difficult process of decoding symbols. Still, as Harris concludes, “Words are symbols that can be used to refer to anything: life, death, love, close friends, time, space, current events etc. If you know what a particular word refers to then you know its meaning, and you can understand it. But if you don’t know what a word refers to then you can’t understand it” (Harris, 2007:50). Even spoken language has problems with symbols adequately communicating meaning. Linguistic scholars Akmajian, Demers et al., demonstrate in their text book for linguistic students, that even within spoken language there is still no single established theory of meaning; rather there are various communication theories each of which covers different aspects of linguistic construction (Akmajian, Demers et al., 2010). If understanding spoken language is problematic, there are greater difficulties in inferring meaning in music.

Music without text, such as instrumental music or *musique concrete*, is not even close to providing the immediate comprehensibility of spoken language. As Budd argues, music as an abstract artform does not contain the two components which enable listeners to make literal sense of speech, namely that it is not “...made of sounds which point [uniquely] to non-auditory meanings, nor composed with syntactic rules” (Budd, 1985:ix). However, this does not mean that music is not intelligible in a more general sense. Music can still ‘make sense’ in an abstract intangible way, similar to the medium of communication-music itself.

Listeners make a deliberate effort to attend concerts, perhaps as a social occasion, or to undertake the listening experience. As Nonken explains, music provides “...an auditory environment to be actively explored” (Nonken, 2008:293-294). Ford suggests, people attend concerts in order to “...concentrate, memorise and engage thoughtfully with the music” (Ford, 2005:4). The question then becomes one of understanding how avant-garde music might make sense rather than scorning it as unwanted and undesirable ‘noise’.

Listeners make sense of music while listening and afterwards by making sense of what they hear. ‘Sense-making’ is an essential response mechanism to music, as it is

to understanding any other manifestation of human behaviour or natural phenomenon. As Weale has clearly identified, insight into any type of compositional idea is an important way by which diverse listeners make sense of unfamiliar and unusual music (Weale, 2006:189-190).

Investigating music from a listening perspective also, as Moore (2003:7) argues, empowers and respects listener responses. Using the broadest possible interpretation, sense-making includes either or both intuitive response and considered opinion. Growing acceptance of diversity in Western thinking (Goleman, 1995; Gardner, 1999) suggests that music can be understood by listeners in many ways. Music can be appreciated for its beauty, usefulness, function, labour input, resources and materials used, without necessarily being meaningful in the same way as a spoken language. 'Sense-making' refers to a process of appreciation or reasoning that occurs only in the listener and does not require any insight or knowledge of specific communicative intent, or compositional methods. 'Sense-making' moves towards a way of thinking about music that is truly inclusive and cross-genre. In music, a sound type can be literally meaningless but in the appropriate context will still make sense. At times, even noise makes sense. Sense-making foregrounds music as a lived sonic experiential process rather than treating the fixed objects of score, LP record, audio file, or computer program, as the music.

However, sense-making is an activity that is separate from composers' 'intentions'. As Guck summarises, sense-making involves awareness of "...how a compositional train of thought might go, not in second-guessing exactly what the composer...thought while he [sic] was writing" (Guck, 1994a:225, note 16). However, as Budd observes in relation to perception of emotion, when someone listens to music they "...infer from the character of the music that the composition...arose from the experience of a particular emotion (Budd, 1985:18). But as Budd clearly spells out "...this would be an inference from the music's audible character..." (Budd, 1985:18). Intentions cannot ever be truthfully discerned either from program notes, even those written by the composer, biographical statements, or from the music itself.

Composers necessarily guide the listener's organisation of the sound stream into music. Even though a listener's perception of possible ideas is influenced by their

individual circumstances and history, as Clarke observes “...an important component is also built into the material properties of the object of perception [music], and is therefore a shaping force (at least potentially) on every perceiver” (Clarke, 2005:125). Composers make choices regarding the materials and design in order to project an idea through the music. The composer decides on a combination of features depending on what the music is intended to express.

These compositional design choices impact on individual listeners’ interpretations. As Nonken explains “It is this power of limiting and guiding perception through what is given and withheld, in music, that determines what we listen for next” (Nonken, 2008:293-294). As Clarke observes, although listeners will read individual meanings into a piece of music, the range of possibilities is constrained by the actual sound of the music (Clarke, 2005:89-90). For example, a structural sequence of sounds holds any or all of these possible readings: music, 18th century music, badly played Mozart, or a sonata. Nonken explains that when one listener ‘hears’ one rather than another of these possibilities in a piece of music, she does not detect a difference in the structure, she only focusses on different features among all those that are available for perception in the sound and structure of the music (Nonken, 2008:287-88). The composer determines how best to illuminate the underlying idea which inspired the work through making decisions about where to place, and how to shape, each sound event according to their desire, taste and skill.

Like all other art practices, music composition is an accumulated set of complex decisions made as the work begins and unfolds into its state of splendour. As several 20th century composers have observed, the materials of music can be distinguished from the techniques of composition (Reynolds; Wuorenin, 1979). There are two aspects to music composition. One is the generation of each individual sound event, the materials of the music, and the second is the compositional technique, the process of “...determining rejections, and accumulating the results of rejections” (Boulez in Deliege, 1976:66). Framed more positively, composition is the design process of arranging sounds over a period of time. However, as Wishart observes, different compositional processes can produce music that sounds quite similar. In reverse, using the same materials and methods possibly ends up with very different music (Wishart, 1996:332). The listener’s experience of the music will also be framed by the title of the music, usually closely

associated and available along with the sound of the music¹⁵, yet also determined by the composer. Ultimately, how a listener makes sense of what they hear is influenced by the compositional design, as well as their self-directed ‘auto-ethnographic’¹⁶ exploration of the sound of the music.

1.3 The Challenges of Making Sense of Avant-Garde Music

Received wisdom is that the paradigmatic positive listening response to Western art music is transcendence. Further, art music is expected to be enjoyable, by being beautiful and emotionally expressive; and the music is expected to make sense without active effort on the part of the listener. The following sections explore the origins and implications of these factors when making sense of avant-garde music.

We could understand the term ‘social function of music’ as the social situation in which the music is being heard. Functional use of music helps to make sense of the listening experience. For instance, what is now commonly called Mendelssohn’s *Wedding March*, was not originally written to function as ceremonial wedding music¹⁷, but as 21st century listeners we hear it as wedding music whether in church or in a comedy show. This could be a new functional use of music to bring about positive experiences through membership of a social group, or perhaps as a means of packaging a product for mass consumption. However, in the 21st century, art music is typically autonomous from direct social function by being located in the concert hall. As a result, as Goehr explains, concert music is necessarily to be understood on its own terms in ways specific to music (Goehr, 1992:122). Locating Western art music in the concert hall has affected expectations of what constitutes paradigmatic listening responses.

By the middle of the 19th century, text was no longer required for important music. Music was no longer valued for supporting and amplifying the meaning of words.

¹⁵ Although other extra-musical information, such as program notes can make a difference to a listener’s response, these are not always easily available to individual listeners, nor accurately report the composer’s intention for the music.

¹⁶ Auto-ethnography is a qualitative research method where generally, the researcher writes with a personal voice and emphasises self-reflective activities to balance their observations of events external to themselves.

¹⁷ This music was originally composed as incidental music for Shakespeare’s *A Midsummer Night’s Dream* but was adopted as suitable music for weddings in 1847 (Kennedy and Kennedy, 2007:809).

Instead, as Cook and Dibben explain, instrumental music had become the paradigmatic model of music (Cook and Dibben, 2010:48). Will identifies that the romantic idealist aesthetic for 'absolute music', established around the turn of 19th century, meant that efforts at representation of nature, even of emotional states, were deemed to be unworthy of serious criticism (Will, 2002:148-149). Further, changes in class structures and the distribution of wealth saw the shift of music from church and court to the concert hall. This meant music composed for the concert hall was necessarily autonomous from direct social function. Thus, there needed to be new ways of making sense of music.

However, modern psychology adds new insights into why individual listeners report transcendent listening experiences. For instance, Parncutt suggests that music can induce transcendent experiences because "...mothers' soundings can affect the emotional state of the foetus, which becomes associated in the babies' minds with transcendent spirituality" (Parncutt, 2009:119). More prosaically, Sloboda and Juslin attribute transcendent experiences to the ambiguous and imprecise emotional cues in instrumental music. This relative 'cue-impoverishment' allows subconscious preoccupations to occupy more mental space than usual because abstract music does not provide enough material for more conscious thoughts (Sloboda and Juslin, 2001:95-96). Alternatively, the problem is that the English language does not have sufficient alternatives with which to express the inherent complexity of 'self', sensation and conscious awareness.

These researchers also recognise that reflective cognition, conscious self-awareness, is required to access and hence verbalise the experience of music (Juslin and Sloboda, 2010:941). As Harris explains in more detail, there are two functional parts of the 'self'. (1) the 'thinking' self, commonly called 'the mind', is the part that plans, thinks, judges, compares, imagines, visualises, analyses, remembers, daydreams and fantasises. It thinks about experience. (2) the 'observing' self is responsible for focus, attention and awareness. It can register, observe or pay attention to thoughts, but cannot produce them. It is also the part that experiences the external world directly through sense perception (Harris, 2007:77-78). Harris goes on to identify that most Western people have little concept of the 'observing' self, so there is no common word for it in the English language. Instead, English uses

the word 'mind' to denote thinking and observing without distinguishing between the two (Harris, 2007:78). As a result, even though researchers in philosophy, psychology or, particularly, musicology may articulate thoughts and verbal insights into the music, reporting the direct experience of 'cue-impovertished' aural stimuli, otherwise known as music, can only be articulated as an ineffable state of transcendence.

As Juslin and Sloboda observe, the concept of the 'habitus of listening'¹⁸ outlined by Judith Becker in her comparative study of cross-cultural differences in behavioural responses to music (Becker, 2001:138; 2010:130), provides useful insights into 21st century 'classical concert culture' and its impact on academic approaches to the study of Western art music (Juslin and Sloboda, 2001:5). They observe that the prescribed behaviour in art music concerts is expected to be silent and respectful listening, with minimal bodily movement or other emotional expression, until the conclusion of each piece of music. Juslin and Sloboda point out that this view of appropriate behaviour when listening to art music arise because 19th century Romantic intellectual and aesthetic responses to music have become part of the 'habitus of listening' to Western art music. These attitudes continue to be an accepted way of approaching Western art music in the 21st century. Western art music is expected, socially and culturally, to produce transcendence. Although these expectations are questionable, as they are cultural conventions rather than logical constructions, they are clearly challenged by avant-garde music. The perception of transcendence as the paradigmatic listening response to Western art music immediately poses the problem of finding other ways to make sense of music that challenges conventional expectations.

a. Avant-garde music tests cultural expectations of art music

An important cumulative side-effect of concert programming that omits avant-garde music is that the music of the past, particularly an established canon of composers and pieces of music, is now regarded as more important than contemporary

¹⁸ Judith Becker is an ethnomusicologist chiefly interested in comparing music traditions across cultures. Becker develops and explores the notion of the 'habitus of listening' to describe the listening habits and expectations of listeners in a particular culture. Becker argues that studying these habits can reveal implicit assumptions about what music is for, what music 'means', and how it is to be perceived, as well as the culturally appropriate responses to the music (Becker, 2010:128-130).

compositions. Unfortunately, this valuing of the 'canon' influences listener reception in more subtle ways. As Juslin and Sloboda outline, received wisdom about particular music influences listener reception in general, not only in response to that specific music (Sloboda and Juslin, 2001:97). For example, the practice of assigning 'greatness' to Beethoven, means that Western listeners are influenced by the concept of greatness as a means of valuing an individual composer's music and have ideas based on Beethoven's music regarding what constitutes 'great' music. Sloboda and Juslin argue that these background concepts affect individual responses when listening to music of any composer (Sloboda and Juslin, 2001:97). Similarly, Barrington, Oda et al., have demonstrated that listeners to popular music¹⁹ pay more attention to the actual sound of the music if they do not know the name of the song or the performers (Barrington, Oda et al., 2009:360). Clearly, *a priori* expectations about the conventions of particular music can affect listening responses to music in well-known genres, including art music.

Avant-garde music does not guarantee enjoyment. Western art music has no higher purpose than entertainment, or as Ravel observes, 'divertissement de-luxe' (cited in Ford, 2005:114), so enjoyment²⁰ becomes an important factor in audience reception. Western art music is by definition performed in the rarefied atmosphere of the concert hall. Locating art music in the concert hall has significant implications for the reception of Western art music in general, and this further impacts on the reception of avant-garde music. Attending avant-garde music concerts may be pleasurable because the concert experience provides benefits of group membership in those audiences. As Sloboda and Juslin identify, contemporary social functions of music revolve around what listening to a particular style of music stands for in terms of being part of a larger social group: the formulation and expression of self-identity, 'prestige effects', and to fit in with social expectations that maintain personal relationships (Sloboda and Juslin, 2001:97). Interestingly, these three uses of the term 'social function' concern the social status of the individual. Presumably, with respect to avant-garde music, the social benefits are only important for a small number of people or else the need to gain support for new music would not exist.

¹⁹ The popular music selected for their research included many styles such as rock, punk, folk, pop, electronica, blues, jazz, soul and hip-hop (Barrington, Oda et al., 2009:359).

²⁰ The concept of enjoyment is taken as meaning finding pleasure in undertaking an experience.

In the 21st century, many people use the internet as a means of finding information, listening to music, and as a means of being part of various social groups. I undertook a quick survey of information available on several well-known websites available to a variety of music listeners in December 2014 and reviewed in October 2016. The informal survey investigated posted information about and listener comments in response to *Concert for Piano and Orchestra* (Cage, 1957-58). This music was chosen because John Cage is relatively well known and this music has been around for fifty years, thus allowing time for diverse listeners to engage with it. My review suggests that avant-garde music is not given much attention, either positive or negative.

The lack of community engagement could be exacerbated by the dearth of easily accessible information about the music on other websites that provide access to music. For instance, it is possible to search the well-known *Apple iTunes Store* via the free *iTunes* software interface but to hear the music requires paying for each track. *iTunes Store* has six versions of *Concert for Piano and Orchestra*²¹ currently available for purchase²² (Apple Pty Ltd, 2016). Despite user reviews being encouraged, there are still no user reviews of this music on *iTunes*, however there is a biography of John Cage under artist information (Apple Pty Ltd, 2016).

Similarly, when searching for the title *Concert for Piano and Orchestra*, the music recommender website *AllMusic.com* returns links to four 'songs' and two 'albums' (AllMusic, 2016/search)²³. There are no reviews by users although several tracks have historical notes about the music and recordings written by *AllMusic* staffers, as well as their personal rating of the recording on a five point scale. This dearth of information is particularly underlined when *AllMusic.com* describes itself as a

²¹ Search conducted with correct spelling of 'Concert'. The website wants to redirect to music listed with the title of 'Concerto' rather than 'Concert', however I did not follow this path.

²² The existence of publicly available music downloading or streaming sites does not necessarily mean free access to the music.

²³ Search conducted with correct spelling of 'Concert'. The website automatically suggests a redirect to queries to music listed with the title of 'Concerto' rather than 'Concert', however I did not follow this path. The results reported here use the search categories supplied by *Allmusic.com* for the six results returned for John Cage's music. These six results appear before the other thousands explicitly credited to other composers, or with other titles. To be completely precise, there is one other 'song' with the same title returned in the top eight results, which on closer inspection, by following the links, has been composed by someone other than John Cage.

“...comprehensive and in-depth resource for finding out more about the albums, bands, musicians and songs you love...[and] reviews...of classic albums...” as well as providing links to accessing the music (AllMusic, 2016/about).

Even specialist online music libraries that require payment of a subscription to access the audio provide little information to encourage listeners to engage with this piece of music. For instance, the *Naxos Music Library* which claims to be the largest online classical music library with 100,000 CDs and 1.5million tracks (Naxos Digital Services Ltd, 2014), includes eight versions of Cage’s *Concert for Piano and Orchestra*, each with an image of the CD title cover only, leaving all the production credits to be noted on the webpage itself. The site does not permit user reviews but there are no critical reviews or program notes provided for information. *Freegal* is a similar subscription service available in various global locations. This service is available free to members of public libraries in Australia. However, there are no versions of *Concert for Piano and Orchestra* available on this website (Library Ideas LLC, 2014), and no information to encourage people to seek this music out.

The lack of engagement with avant-garde music is also demonstrated on *YouTube* by the very low numbers²⁴ of people starting to listen to *Concert for Piano and Orchestra* (Cage, 1957-58), let alone the miniscule number of users who are either unable or unwilling to comment on this music. This is so unlike contemporary 21st century social culture where users for some time have readily and speedily commented on everything, for instance on current affairs websites²⁵ or on Amazon products²⁶ or Reddit²⁷ or Facebook²⁸. The statistics for these websites show that

²⁴ The first video of *Concert for Piano and Orchestra* to be posted on *YouTube* is also the most popular. This video received 39,000 initial views in 4 years. It has received 25 comments in that time (YouTube LLC, 2016).

²⁵ Such as those hosted by the Australian Broadcasting Association which show over 40,000 comments since 2006 (Australian Broadcasting Corporation, 2014).

²⁶ On 29 December 2014, the lead advertisement on amazon.com was for a digital video receiver, offered for sale through the site for nine months. At this date, the digital video receiver had generated 16,180 reviews and 22,762 people read these reviews in less than one year it has been posted. A follow up in October 2016 shows this product is no longer available for sale, but in the meantime garnered 33,183 direct reviews (Amazon.com Inc, 2014, 2016).

²⁷ Similarly, the home page of reddit.com shows the most popular posts based on the number of comments. At the moment of access, 29 September 2016, an article about *Rockstar* posted eight hours previously already received 1991 comments, while the whole website had 234 billion visitors in December 2015 (reddit inc, 2016).

²⁸ Facebook reports an average of 1.13 billion daily active users for September 2016 (Facebook, 2016).

hundreds and thousands of users are commenting frequently and instantly on many different topics. The low number of on-line comments on *YouTube* and *iTunes* could be due to listeners disliking the music, as Barrington, Oda et al, have demonstrated that listeners will not attempt to evaluate music they don't like (Barrington, Oda et al., 2009:361). However, at least in part, this problem is cyclical because online users are not even listening to the music in the first place, which can be partly due to the lack of easily accessible information, let alone positive comments²⁹.

Ultimately, solving the market problem requires avant-garde music to be valued by diverse listeners. Increasing audience sizes may arise through new sales pitches and appropriate marketing tools. However in the socially networked world of the 21st century the most important factor may be generating interest in and providing positive experiences of listening to avant-garde music. Valued experiences may sell themselves.

The problem then lies in the provision of positive experiences of avant-garde music, particularly, as Budd observes, "...if music is not rewarding to listen to, then although it may have other kinds of value, ...it lacks an important value" (Budd, 1985:17). Watson has demonstrated that audience response is clearly related to listeners' liking for music, and by the specific attributes of the music (Watson, 1942:40), but is not affected by age or music training (Watson, 1942:42)³⁰. Apparent difference between trained and untrained listeners occurs only because trained listeners tend to articulate enjoyment as an aesthetic response rather than simple 'liking' of the music (Payne, 1980:38)³¹. Nonetheless, the aesthetic response articulated by trained listeners clearly contains an evaluation based either on their own enjoyment, or the perceived potential of the music to provide enjoyment to other people (Payne, 1983:100). Therefore, music training provides a greater

²⁹ iTunes Genius, another recommender system in part relies on user comments, as well as sales numbers, to prioritise its recommendations to users for additional purchases they may like to hear (Barrington, Oda et al., 2009:359).

³⁰ Watson's experiments included nearly 60 excerpts of vary diverse orchestral music ranging from Scarlatti to Schoenberg, with his experimental subjects ranging in age from year 4 school children to adults with and without music training. Although Watson was not directly concerned with music familiarity, it is safe to assume that at least some of the music would be unfamiliar to most participants (Watson, 1942:8).

³¹ Instead of 'liking' or enjoyment, listeners with more music training articulate technical aspects of the compositional design and their aesthetic response. Perhaps this explains Babbitt's own emphasis on listening for identification of technical features in the music, rather than seeking ideas.

command of technical language to describe aspects of music, which may be put to use in particular listening situations³², but does not influence a listener's liking for the music.

We expect music to be beautiful, which means that the social constructs of 'musical' and 'beautiful' may have an immediate impact when listening to avant-garde music that contains loud, ugly or anharmonic sounds. Such music can be expressive of something, such as anger, agitation, or nuclear war, even if the idea is not usually associated with 'beauty'. Alternatively, the music may be exploring these difficult sounds for abstract inherent beauty of shape, pattern, colour or texture, which can become apparent while listening and appreciated as beautiful and musical outside of traditional expectations.

The idiomatic use of the term 'musical' builds specific expectations because of grammatical usage. However, 'musical expression' can simply indicate that the expression is occurring through the medium of music, similar to using the term 'facial expression' to indicate in a straightforward way that the expression is occurring through the medium of the face. However, in other contexts, it becomes easy to interpret 'musical expression' so that 'expression' as the key object of the phrase, when qualified with the adjective 'musical', means the expression was particularly beautiful or harmonious, for example 'musical bird-song'.

The term 'expression' often seems to refer to a discrete feature that can be dispassionately observed such as 'rhythm in music' or 'melody in music' both of which are intrinsically music-specific. Hence, we are led to expect that expression is embedded in music in a similar way. This somehow overlooks the reality that music is the medium of expression, rather than expression being a component of music. Music can express 'things', whether it be an idea, an emotion, the state of the natural world or the glory of god, or pure investigation into a particular compositional process. Yet the idea being expressed is realised 'through' music as an alternative to other media such as dance, photography, or words. This is how 'expression' is understood in this thesis, which ensures that contemporary compositional techniques and technologies are

³² Trained listeners significantly alter their articulated response to art music depending on the circumstances of listening (Payne, 1983:98).

incorporated into the new method. Any avant-garde music has the potential to be expressive and beautiful, no matter its materials, methods or originating idea.

Some musicologists are quite free in their use of the terminology of expression. This is at odds with the apparent purpose of the writing, such as providing detailed musicological analysis of style, form, or genre through a rational line of reasoning built on documented supporting evidence. For instance, Griffith's book on the evolution of the string quartet suggests that "...the prominence of major and minor in a single movement, can be used to achieve expressive extremes..." (Griffiths, 1983:76). This echoes Barth's work on the impact of the metronome on performance practice, in which he reports Beethoven's insistence that performance of his music requires small scale tempo modifications, detailed amplitude changes, and specific articulation to make the music expressive (Barth, 1992:158). Again, the term reflects some type of indefinable experience as there are no clearly articulated ideas about what this word means, or consistent evidence that could provide insight into implied meaning.

In contrast, some musicologists are very careful in their use of 'expression'. For instance, throughout a 4000-word explanation of his approach to analytical interpretation of Beethoven's string quartets (Chapter 2 in Kerman, 1975), Kerman uses the word 'expression' only three times. Even though he is obviously discussing compositional practice and 'expressiveness', he does not explicitly acknowledge the linkages. This leaves him plenty of room to move and expound his views on any part of the music as he sees fit, without shedding any light on how 'expression' arises. No matter how hard musicologists such as Kerman present thoughtful discussion with apparent rationality, ultimately the commentary on individual musical works remains as individually subjective as those who use the terminology of 'expression' quite freely.

'Expression' may be a slippery concept to pin down because analysts perceive that describing music as 'expressive' is more acceptable than writing about their personal engagement with the music. Indeed, it seems that the Western notion of authority is grounded in the idea of being unemotional and detached, with the presumption that this brings objectivity to the matter at hand. Researchers in various other disciplines have established this point. For example, Lynch and

Haney's research into legal decision-making explains that "...the operative 'deliberative ideal' expects jurors to compartmentalize, neutralize and ignore their emotional responses in order to make 'impartial' individual and group judgments" (Lynch and Haney, 2014:21). Similarly, in everyday communication in Western countries, Brody and Parkin each separately establish that men, when using the written word to communicate, are much less likely to express strong emotional responses than are women (Brody, 1999:35; Parkins, 2012:55), particularly in cases where the person being addressed is unknown to the author (Brody, 1999:75). Moreover, throughout the Western world, men are far less comfortable expressing the more poignant emotions of sadness, grief or depression (Brody, 1999:94). Together, these factors are likely to impact on the way that individual participants in music discourse will communicate emotional responsiveness to music, preferring instead to write about a vague non-specific quality of 'expression'.

However, there are several other reasons critics may be unable to reveal their emotional response, to the music. There are varying degrees of comfort with, and self-awareness of, emotion among individuals. Harris, a psychologist, points out that, "Everyone has emotions and feelings regardless of being in touch with them, or being able to express them in words" (Harris, 2007:101). "We are always experiencing emotion of some sort, just as there is weather of some sort, although sometimes it isn't strong enough, or distinct enough for us to describe it or perhaps even to notice it" (Harris, 2007:101). Harris also observes that there are individual differences in desire for and tolerances of emotional connection (Harris, 2007:101). For some people, an intellectual connection with objects or other people is sufficient.

Expression and engagement are not identical but are closely related activities in that something that is expressive is likely to be engaging, as the features described as expressive are likely to ensure that engagement happens³³. This is clarified by

³³ Based on the suggestions generated by a thesaurus in a common word processor, 'expressive' could be replaced by three main words: mobile (with associated words: animated, communicative, open, easy-to-read); meaningful (with associated words of significant, dramatic, emotional, sensitive, vivid, telling); and representative (with associated words: representing, demonstrating, signifying, indicative of, indicating) ("expressive" in Microsoft Word 2013 Thesaurus"expressive"). Similarly, 'engaging' could be replaced by attractive (with associated words of appealing, charming, winning); connecting (with associated ideas of fitting into place, attaching, joining, uniting, bonding); holding (with associated words of keeping, absorbing) ("engagement" in Microsoft Word 2013 Thesaurus"engagement").

observing that the opposite of expressive is categorised as blank, cool, aloof, deadpan, giving nothing away, unemotional, secretive, or enigmatic. Yet these characteristics could be expressed through music, in which case that music would be 'expressive'! Together these aspects of cognitive appraisal may impact on a listener's personal reaction to music, and how they denote that experience in terms of music and its 'expressiveness', particularly analysts, as they are trained listeners steeped in the 'habitus' of the classical concert culture.

b. Avant-garde music requires active and attentive listening

Making sense of avant-garde music requires attentive listening and active engagement because each piece of music needs to be considered on its own terms. This has arisen through overall changes in cultural expectations of the composer as an individual, which reflect the social mores in which they work; and through the impact of technology on performance practice.

Changes in performance practice over time have impacted on the transparency of avant-garde music and the effort required of listeners to make sense of abstract music without text. Juslin and Persson demonstrate that listeners determine the character of individual music through the interaction of all the attributes of music (Juslin and Persson, 2002:225). Juslin and Laukka (2003) conducted a comprehensive literature review of empirical research results into the attributes of speech that communicate specific emotions in comparison with the attributes of music which communicate specific emotions. As Juslin and Laukka observe, music has more attributes than speech, such as simultaneous aggregations of notes in various registers and harmonic progressions over time (Juslin and Laukka, 2003:774). Linguists have clearly established that tone of voice is very important in the processing of speech for meaning and the recall of words when used in different contexts (Nygarrrd and Lunders, 2002:591). Juslin and Laukka's extensive review of experimental research into 'musical' expression and expressive speech suggests that listeners generally make sense of music without text with the same mechanisms used in everyday life to make sense of human speech. Specifically, listeners make sense of speech by listening for 'tone of voice', which is assessed by means of the interplay of three independent attributes: amplitude, tempo and timbre (Juslin and Laukka, 2003:774-775). Additionally, Bresin and Friberg demonstrate that, similar

to interpreting speech and singing, listeners use the relative duration between long sounds and short sounds to perceive emotions in conventional instrumental music, along with the attributes of amplitude and tempo (Bresin and Friberg, 2000:59). As Scholes observes, nuances in event duration and event separation help emphasise some sound events against others, indicating which sounds are more important in a particular section of music ('Agogic', Scholes, 1970:20). Without nuances in timing and accentuation between sound events then relying on 'tone of voice' to make sense of music may no longer be possible.

As a result of 19th century change in performance practice³⁴, 20th century composers and performers have become accustomed to and accepted mechanical clock time as appropriate time keeping for their work, resulting in written note durations having very similar actual durations in performance. Computer music, based on the quartz crystal time-keeper and numerically based programming, easily produces crisply precise regularity of sound events. Indeed, as Barth argues, metronomic music³⁵ may still "project the form", but it eliminates the particular 'character' of the piece (Barth, 1992:1-2). If 'character' is no longer useful in making sense of avant-garde music, then this music requires active listening. As Nonken argues, active listening enables listeners to make sense of the music in their own way (Nonken, 2008:287). Therefore, although the actual ideas in avant-garde music can be clearly articulated and can make sense, listeners are required to closely observe and integrate details of individual events as the music unfolds, if they are to make sense of the experience.

After a century or more of individual idiosyncratic sounds and metronomic time keeping, even though music is not a language and is more complex than speech, lack of expected mechanisms of emphasis can make avant-garde music more challenging to experience and more difficult to comprehend without focussed conscious awareness on how individual sound events combine.

³⁴ Late 19th century performance practice of strict tempo, through the impact it has on music as heard by later audiences, especially in the 20th century, may have significantly influenced the practice of 'new music'. Barth argues that invention of the metronome in early 19th century had a huge impact on performance practice during that century, since adoption of metronomic time tends to produce a constantly maintained tempo throughout a single piece of music. Barth argues that ideas of rhetoric in music through both composition and performance practices were influential in most Western art music until mid-19th century. Rhetorical devices include large and small changes in the speed of delivery to produce 'affect' (Barth, 1992:1-2).

³⁵ Although composers of avant-garde music predominantly require that performers maintain strict time, any music will be metronomic if performed in strict tempo.

Summation

My research investigates whether fuzzy logic is a useful approach for making sense of a stream of sound by through generating visual representations of a personal listening experience. As Straus (2015:3) observes, despite Forte's introducing the concept of similarity measures in 1973, there are still no similarity measures widely used in 21st century music analysis . This thesis argues that fuzzy logic, with its ability to capture degrees of similarity in several dimensions simultaneously, is a useful and informative way to visually represent the complexity of an individual's subjective experience of a piece of music. The discussion in this chapter has explored some reasons avant-garde music can be considered 'difficult'. Therefore, avant-garde music provides fertile testing ground to demonstrate fuzzy logic in dialectical listener-oriented music analysis.

In summary, there are many reasons for using avant-garde music to build and demonstrate a new method. First, avant-garde music tends not to rely on conventional scoring of pitch and rhythm; hence, the only way to get information about the sound of the music is by listening. Second, it is highly likely that each individual piece of avant-garde music has never been heard before, so it can be approached with fresh ears and open mind. Third, avant-garde music contains unusual sequences of unusual sounds which may include 'noise', so it challenges descriptors based on standard music theory. Fourth, each piece of avant-garde music needs to be taken on its own terms as different composers challenge the status quo in different ways. Fifth, the experience of avant-garde music may not fulfil conventional expectations of listening to Western art music because it does not allow 'unconscious' listening which allows for transcendent experiences or the music may be concerned with ideas rather than emotion. In addition, avant-garde music can require active listening because it may not rely on 'tone of voice' to implicitly convey some sense of the idea. Further, avant-garde music challenges the status quo so conventional music theory may not provide a great deal of insight into this music. Finally, this is the music of our time and as a composer I am interested in exploring potential new tools to use in my algorithmic compositions. All these reasons suggest avant-garde music is a good genre for testing whether my application of fuzzy logic helps to make sense of music. The results will provide

material for discussion regarding whether this application of fuzzy logic is useful in practice, and whether *Fuzzy IDEAS* as a method works at this exploratory level.

Even though the impact and implications of the thought revolution of the 20th century remain full of possibilities still being explored by composers in 21st century Australia, there is little desire by diverse listeners for the experience of new music. The underlying problem is that listeners tend not perceive avant-garde music as music. As Becker explains “Audiences will select what will occur as artwork by giving or withholding their participation in an event or their attention to an object, and by attending selectively to what they do attend to...” (Becker, 2008:214). Avant-garde music is challenging because the audience must work harder to understand music that is unconventional, which has been so recently composed, is unique by design, literal rather than figurative, reveals beauty in unconventional ways, and challenges the concert-going ‘habitus’ of transcendence. None of these reasons means that avant-garde music does not have value, and cannot make sense if we have appropriate and useful tools with which to approach the listening experience.

It is almost self-evident that different listeners enjoy music for different reasons. As Bayles and Orland discuss “[The audience is] in a good position to comment on how they are moved (or challenged or entertained) by the finished product, but have little interest or knowledge in your *process*” (Bayles and Orland, 1993:47). Moore explains that the political position of valuing the audience ensures that the experience of the music is foremost, rather than the compositional techniques (Moore, 2003:6). Focussing on ‘sense-making’ validates the listening experience as an interpretive act without requiring a detailed understanding of every possible listener response. The concept of ‘sense-making’ allows for multiple ways of understanding how any sensory or intellectual experience can be perceived as effective without the precision required for the linguistic orientation implicit in ‘meaning’. Sense-making only requires that the listener conceive there is something, an idea, informing the music. This idea provides the listener with a framework for turning the stream of sound into music. Although it is possible for listeners to make sense of music without enjoyment, yet the antithesis is nearly certain: if listeners cannot make sense of music then there is no possibility of enjoyment. Searching for meaning in music is not new. However, our understanding of how music makes sense still remains incomplete.

Chapter 2. Existing Approaches to Listening as a Sense-Making Activity

This chapter considers what existing music discourse tells us about the lived experience of listening to a piece of music. This chapter is focussed on how existing academic approaches and concert presentation practices deal with the uncertainty of interpreting music without text. I look at psychology which looks for human response mechanisms within the listener; and musicology which looks to mechanisms within the music, typically represented by its score. In addition, the importance of making sense of music has been recognised by music producers, who have developed other methods intended to assist listeners make sense of Western art music. Composers, performers or concert promoters frame interpretation by using titles for individual pieces of music, program notes and commentaries regarding the composer, her intentions and her environment. Despite each approach providing a different perspective on how music can make sense, even combining these different focal points still does not give us a clear understanding of how the perceived features of a piece of music as it unfolds in real time are associated with the idea(s) that make sense of that experience for that individual.

2.1 Psychologists Look to Our Common Humanity as Listeners

Music psychologists and, later, systematic musicologists have been working to understand the commonalities of listener responses to music. ‘Music psychology’ can be defined as research “...concerned with understanding the psychological processes involved in listening to music, playing music, composing and improvising music, using empirical, theoretical and computational methods” (University of Oxford). Although recognition of music psychology as a discipline within the English-speaking world is very new¹, psychologists are the pioneers of empirical research into the impacts of listening to music. Psychologists observe human behaviour and then search for response mechanisms that are common to many people. As Sloboda and Juslin explain, experimental psychology in music uses the

¹ For instance, music psychology has only received recognition through dedicated staff in the Faculty of Music at Oxford University in 2007.

scientific model of gathering seemingly valid and reliable statistical evidence by observing many individual listening experiences under strict test conditions (Sloboda and Juslin, 2001:71). This can then be used to infer general conclusions about human responses. Sloboda and Juslin explain that observed behaviour can be caused by one or more physiological response, cognitive response, or consciously intentional actions (Sloboda and Juslin, 2001:72). Certainly research by empirical musicologists occurs, for example Halpern (1992), Weale (2006), and Parncutt (1999) among others. The research methods are similar to psychological investigation, based on scientific experimental methods to provide seemingly valid and reliable inductive insights into audience reception/listener perception.

The weight of numbers is designed to overcome the 'subjectivity' of single person responses to music stimuli. Yet, the validity of empirical experiments is challenged by the necessity of designing experiments to test one factor at a time. The selection of music stimuli, and the selection of listeners, can often remove the music and the listening experience from real world concert conditions. Inductive research methods that rely on statistical analysis often require that real music isn't used, and that the listening occurs under laboratory conditions.

The first consequence of this type of testing is that typically respondents are not representative of the whole of the listening population², nor are individual differences within the respondents examined for their potential impact on listening responses. As Clarke discusses, even research focussed on differences in responses between listeners with and without formal music training is primarily conducted on university students who are not necessarily representative of the whole population (Clarke, 2005:193). Additionally, as Sloboda and Juslin explain most research neglects to account for other factors with the potential to affect individual listening responses such as age, gender, personality, training, current mood, familiarity with the music, and musical preferences (Sloboda and Juslin, 2001:95-96). While these factors have may have little effect on responses compared with the effect of the

² A notable exception is statistically-calculated representative sample study of the Swedish population designed to investigate listener's views on why (including a range of situational factors) listening to a piece of music induced their emotional response (Juslin, Liljestrom et al., 2010). Similarly, another exception is a study based on a sample of the whole population, conducted in Belgium into how people might use an online music retrieval system focussed on the types of descriptors that listeners are most likely to use when talking about different genres of music (Lesaffre, De Voogdt et al., 2008).

music, it does suggest that the outcomes of empirical research results are not yet clearly established. There is room for more and different listening experiments.

There are other ways that laboratory-based experiments impact on listening responses. Firstly, as Payne demonstrated, listeners with music training significantly alter their articulated response to art music depending on the circumstances of listening (Payne, 1983:98). This shows that at least one set of respondents answers differently when they are aware that their responses are being monitored. Additionally, respondents might attend to the music differently than they would under their own regular listening conditions, resulting in different results than would occur in real world listening. As Juslin and Sloboda conclude, there is still a need to develop more reliable measurement tools (Juslin and Sloboda, 2010:938). In particular, Emery Schubert (2010) argues that continuous recording of responses is required to capture changes in responses as the music unfolds over time. Gabrielsson and Lindstrom also argue that “...free descriptions should be used more frequently...since many of music’s characteristics are so variable, multi-faceted and subtle...” (Gabrielsson and Lindstrom, 2010:394). Thus the researchers themselves suggest that present methods of empirical research do not yet produce clear cut results on how particular aspects of music impact on listener reactions.

There are other limitations in the research due to the types of questions being posed. Many research questions assume an apparently self-evident truth that the primary response to music listening is stimulating emotion. However, psychologists still need to develop and use “...more refined techniques for separating the perception of emotion in music from its emotional effects on listeners” (Juslin and Sloboda, 2010:938). It is possible to perceive that the music is communicating an emotion, without listeners actually feeling that emotion. There is also a range of indirect emotional responses such as creative or spiritual responses, or even indirect impacts on mood and behaviour rather than conscious thoughts. Emotion is not always reported as the experiential response to listening. There can be other ‘vitality effects’³, related to emotional responses that are not directly emotion-based.

³ The term ‘vitality effects’ was initially articulated by Daniel Stern (1985:54), drawing on the work of Susanne Langer, a philosopher concerned with questions of art work as a symbol of knowledge, and why does art require ‘vitality’ or the semblance of being alive (Langer, 1967:xv). Gabrielsson and Lindstrom adapt Stern’s (1985:54) definition of ‘vitality effects’ to music as listener responses to

Furthermore, "...music is not inherently emotional. It is the way that we hear it which makes it so" (Sloboda and Juslin, 2001:98). However, many psychology research questions assume that listening to music stimulates only emotion.

Indeed, decades of empirical research by psychologists has established that trained musicians and untrained listeners are equally capable of hearing diverse ideas⁴ in a range of art music (Watson, 1942; Payne, 1973; 1980; 1983) including avant-garde music (Weale, 2006). However, these same empirical researchers repeatedly discount these responses in favour of focussing their research on emotion. For instance, Watson's principle study was confined to the mood character of the music, with his bald statement that musicians say this type of meaning is the most important (Watson, 1942:2, note 4). His emphasis on emotion is at odds with his own pilot study showing that listeners across a broad range of ages and music experience found a range of meanings in diverse excerpts of music⁵. Similarly, Payne's studies are primarily concerned with precise characterisation of reported emotional responses to music, even though continually acknowledging that other responses do occur (Payne, 1973:178; Payne, 1980:39; Payne, 1983:78). And again, Juslin and Persson only review literature concerned with emotion despite recognising the myriad ideas which are embedded in music (Juslin and Persson, 2002:220) as do later researchers reviewing empirical experiments on the impact of structure on listener response (Gabrielsson and Lindstrom, 2010:368). This occurs despite recognition by psychologists that texts on music, from ancient Greek philosophy to experimental evidence of the 20th century, clearly identify a variety of ideas about what music is able to express. Their research shows that in addition to emotion, music is thought able to express beauty, motion, expressive form, energy, tension, events, religious faith, personal identity, human character, and social

simultaneous changes in several technical attributes in the sound of the music. These researchers observe that composers decide on whether single or combinations of changes are to be made, and also whether these changes are gradual or abrupt. Gabrielsson and Lindstrom also follow Stern's descriptors of vitality effects to explain that listeners articulate these vitality effects by using "...dynamic, kinetic terms such as 'surging', 'fading away', or 'drawn out' " (Gabrielsson and Lindstrom, 2010:393-394).

⁴ Broader extra-musical ideas proposed for specific music includes a story, a picture, image or design, or the composer's character (Payne, 1973:179; Payne, 1980:31; Payne, 1983:98; Weale, 2006:200).

⁵ Watson's pilot study responses ranged from directly observing technical features, such as 'this is a high note'; to imaginal and associative, such as 'this sounds like a thunderstorm'; to how the music is affecting the respondent, such as 'the music is making me depressed' (Watson, 1942:1-2).

conditions (Sloboda and Juslin, 2001:93; Juslin and Persson, 2002:220; Gabrielsson and Lindstrom, 2010:367). Clearly, emotion is not the only idea that can be suggested by music. Yet, psychology researchers seem to listen only for emotional responses.

Several explanations for the research focus on emotion to the exclusion of all other ideas has been put forward. Clarke suggests this is because conventional approaches to music appreciation, i.e. the story that music and emotion are inextricably intertwined, particularly impacts on empirical researchers who may have not had more than a few years' music training as part of their general education before specialising in psychology. He suggests that these cultural assumptions can become unquestionable truths, particularly when investigating the music most thought to be autonomous from everyday life, namely Western art music (Clarke, 2005:205). By contrast, Juslin and Sloboda attribute the preoccupation with emotion to a lack of reflexive insight into listening response. They suggest that "...‘affect’ can appear to be an objective fundamental characteristic of the music like other aural effects such as pitch, at those times when what is being experienced is so deeply embedded, whether because of cultural or biological reasons" (Juslin and Sloboda, 2001:4). For all these reasons, listening responses that do not directly reflect emotional responses are not captured by the research. As Juslin and Sloboda conclude, it is important to extend research questions to include all types of listening experiences, not only emotional responses (Juslin and Sloboda, 2010:940).

In real life listening, listeners listen to complete pieces of real music with its inbuilt complexity of interdependent changes in attributes over time. However, the nature of empirical investigation requires clearly and well defined test methods to ensure that results are based on uncontaminated data. Thus, empirical research can be limited in scope. First, technical attributes of music are studied only at the binary extreme levels. For example, in relation to Amplitude, the only possible responses included in the research are 'loud' and 'soft', without including at any intermediate stages, such as *mezzo-piano* (moderately soft). Second, transitions from one level to another are omitted. For example, *crescendo* (gradually getting louder) refers to changes in amplitude over time. All of which is completely unrealistic as lived experience of listening, as "Practically any piece of art music demonstrates the composer's use of such changes-abrupt or gradual-for expressive purposes"

(Gabrielsson and Lindstrom, 2010:392). Finally, there is no research into the effect of simultaneous combinations of an attribute, for example different amplitudes in different parts of the texture. From a compositional perspective, which sees music as a means of communicating ideas through the medium of sound, it seems strange these vital aspects of music as it is experienced in everyday life, and in concert-like settings, have been overlooked.

A useful overview of the current range of psychological mechanisms that impact on listening responses shows an awareness that factors outside of the music, including broad social factors such as cultural learning, and internal physical factors within the human nervous system, also impact on experimental results. In particular, Juslin, Liljestrom et al. (2010) have reviewed experimental psychological research concerning the way music may induce emotion in listeners⁶ as well as conducting their own population-wide survey of Swedish listeners. On the basis of their literature review, Juslin, Liljestrom et al. identified seven psychological response mechanisms to listening to music ("Psychological mechanisms by which emotional responses are induced in listeners" Table 22.3 in Juslin, Liljestrom et al., 2010:625-626). This original table contains information relevant to neurological studies of emotion. Because of my emphasis on realism in providing an account of a single personal experience of the music, those factors of most interest are those that impact on listeners in a concert-style setting, including current thinking regarding how each different response mechanism is activated; the time it takes for each response mechanism to be activated during listening; the kind of information which triggers this mechanism; how much each mechanism can be affected by cultural learning; the possibility of conscious control; whether this listening response can be consciously articulated; as well as the degree to which the other mechanisms interact with each specific mechanism. While the degree to which Juslin, Liljestrom et al., conceptualise the effect of each factor on our ability to articulate responses is to some extent arguable⁷, their work shows that some parts of listening responses

⁶ In particular, their review makes a distinction between literature which focusses on recognising the emotion in a piece of music which Juslin, Liljestrom et al. term 'cognitive appraisal' and the literature which addresses the induction of emotions in listeners (Juslin, Liljestrom et al., 2010:606).

⁷ For example, Juslin, Liljestrom et al., suggest that 'rhythmic entrainment' is not available for conscious articulation, I suggest that spontaneous foot-tapping as a physical response while listening is a common type of rhythmic entrainment that could easily be available to self-reflexive awareness.

depend on the particular attributes of the music; by shared physical mechanisms that are parts of our common humanity; but that others vary between listeners and cultural learning regarding listening as an activity.

Nevertheless the 'ecological validity' of many listening experiments can be limited in several ways. Gabrielsson and Lindstrom have stated concerns that listening experiments frequently do not use real music, and that using real music could significantly impact on the validity of conclusions regarding the effects of individual technical attributes on listener responses. As they observe, when real music unfolds over time, several technical attributes usually change in conjunction with each other making it difficult to isolate the effect of one attribute (Gabrielsson and Lindstrom, 2010:370). Further, as Juslin and Sloboda observe, laboratory testing means that there has been little research on how listener responses change over time when listening to "...longer pieces of music that may have varying expressive content...[as well as examining] the final response of the listener to a long piece of music such as a symphony which has many different emotional resonances" (Juslin and Sloboda, 2010:942-3). Thus, as Juslin and Sloboda conclude, current experiments have yet to capture naturalistic behaviours that occur in the real world, rather than under laboratory conditions (Juslin and Sloboda, 2010:939). In summary, despite its shortcomings, empirical research shows that diverse aspects of individual listening experiences can be reported as making sense whether through the perception of ideas, including but not only emotion, or as felt sensation, including but not only, mood and 'affect'.

2.2 Musicology Looks for Meaning Within the Music

As a counterpoint to psycho-acoustic empirical research, research in musicology is typically a more conjectural, theory-based investigation of music. Musicology, in general, is less concerned with people, especially listeners, and rather more concerned with discussing the attributes of particular types of music as an autonomous object. As Clarke explains, psychology is concerned with finding general rules applicable to all times and places about human behaviour and mental life (Clarke, 2005:8) while musicology is concerned with particular manifestations of music in specific times and places (Clarke, 2005:9). Typically, the primary means of

musicological research is a series of case studies of individual pieces of music. Music is analysed for technical attributes, which are then used to argue that a specified analytical method provides insight into particular compositional practices.

Musicology can be broadly defined as the study of music rather than studying shared human listening responses. However, there is no globally accepted definition of the scope of musicology as a discipline. As Moore explains, musicology in Britain means the study of all aspects of music, hence it includes all aspects of theory as well as music history. In America musicology tends to be restricted to the study of the history of Western art music, while all other aspects of music enquiry have been labelled as distinct disciplines, such as theory and analysis (Moore, 2003:2, note 1). Further, as Parncutt argues, 'systematic musicology' has always been an important part of musicological study in Central Europe, and it would be valuable to include its methods in musicology research across the Western world (Parncutt, 2007:1-2). Parncutt locates systematic musicology as "...a subdiscipline of musicology that is primarily concerned with music in general: what is music, what is it for, and why do we engage with it?...which involves both science and the humanities" (Parncutt, 2007:3). Parncutt's argument is that systematic musicological research is being carried out in equal volume to historical musicology and ethnomusicology but is generally not located within mainstream musicology discourse (Parncutt, 2007:2). Thus difficulties arise in determining the scope of musicological research. Therefore, as Tagg observes, the best way of distinguishing musicology from other social sciences, is that musicologists study music as an object, focussing on the technical or structural features of music, rather than studying how music functions within broader cultural or sociological explanations about human society (Tagg, 2012:3). Essentially, different musicological approaches revolve around the attributes of music under analysis; the location in which evidence for how the music makes sense is sought: extrinsic to the sound of the music, or intrinsic, or both. For instance, evidence proffered can range from individual researcher's analysis of a piece of music to illustrate their method; to systematic musicology based on statistics-based empirical evidence; and to cultural or historical studies to contextualise the music that may or may not refer to contemporary reception. These are different approaches to the twin problems of incorporating subjective

responses, and managing the complexity of music as a time-based intangible artform designed to communicate any of a broad range of ideas.

Musicology in general accepts the idea that meaning in music must reside either inside the music (formalist) or outside the music (cultural and historical contexts) (Curry, 2013:179), although Clarke's ecological listening (2005) recognises that listeners make sense of music through its performance context (Clarke, 2005:8) and that they hear all sorts of things in the music not just technical music details (Clarke, 2005:158-159). However, as Moore observes, the primary issue facing any analyst is deciding which and how differences between sections, or pieces, of music are significant, so that "...analysis is an issue of interpretation" (Moore, 2003:6). This acknowledgement then raises the additional question of "...what is analysis actually interpreting?" (Moore, 2003:6). Thus the underlying assumption of musicology is that music makes sense and that the purpose of study is to investigate how particular features of specific music contribute to this outcome.

A chronological overview of mainstream musicological approaches to understanding Western art music, enables us to focus on those which set out frameworks for how specific pieces of music might 'express' ideas. As Cook and Dibben explain, both academic musicology and everyday discourse about music use 'expression' to refer to the affective nature of particular pieces and to the playing of performers (Cook and Dibben, 2010:46, note 1). Musicology does not attempt to reconcile these aspects of terminology, or to extend the concept of expression beyond 'affect'.

This focus on 'affect' is a continuous thread throughout texts on music, although the connotations and implications of this word has changed, as we have come to understand emotions and the purpose of music in different ways. Cook and Dibben explain that ancient Greek philosophy has been a constant point of reference whatever the dominant paradigm of music (Cook and Dibben, 2010:46). They write that the ancient Greeks had two perspectives on the function of music. *Mimesis* is an imitation or transformed reflection of an extra-musical reality which means mimetic music contains information about the real world (including various basic emotional states such as joy or sadness). Thus the value of mimetic music lies in how well it portrays this information, e.g. how the music demonstrates, or performs 'sadness', while "...*catharsis* (purification of the soul through affective experience) means that

the value of music lies in its [actual] effect on the experiencing subject” (Cook and Dibben, 2010:47). It seems that this distinction holds constant throughout the eras of Western art music, even though there have been quite significant changes in the dominant view of the role of music without text as an ‘affective’ practice.

During the Baroque period the paradigmatic purpose of music was simply to support the affective content of words in vocal music. As Cook and Dibben explain, until the middle of the 18th century the role of instrumental music was only to support and amplify the emotion present in the songs’ lyrics (Cook and Dibben, 2010:48). Pure instrumental music had no meaning intrinsic to itself. Although, consistent with the prevailing 17th century view of music as rhetorical discourse, the ‘doctrine of affections’ as it is commonly called, provides a strategy for composing and making sense of abstract instrumental music. The ‘doctrine of affections’ posits that particular musical elements represent and convey various moods and will communicate these to the listener thereby influencing listener response, but interpreted intellectually on a rational level, rather than as felt emotion (Buelow, n.d.). The goal of composer, and performer, is to portray these ‘affections’ accurately. Composers must use suitable stylistic tools across all elements of music⁸ in consistent manner across a single section or a whole piece of music (Buelow, n.d.). However, Baroque composers and theoreticians did not work with one common method; rather there were many alternative explanations about the affective impact of specific technical features of the music (Treitler, 2011:238). As Strunk and Palisca individually document, various codes of signification developed which cover not only performance practice but also compositional practice (Strunk, 1965; Palisca, 1991). Although the idea of rhetorical discourse remained constant, how this could be manifested in practice was open to debate.

As the debate about the aesthetics of music unfolded, the paradigmatic purpose of music changed significantly during the 19th century. As Cook and Dibben explain, by the 19th century, purely instrumental music without text became important in its own right. Music was no longer valued by the way it supported and amplified the meaning of the words (Cook and Dibben, 2010:48). As a result, symphonic and

⁸ Buelow names these elements as “...scales, rhythm, harmonic structure, tonality, melodic range, forms, instrumental colour” (Buelow, n.d.).

chamber music were, and are still are, even in the 21st century, perceived as more important and culturally significant than opera or oratorio. Further, during the 19th century, Western instrumental music came to be seen as “...uniquely privileged among the arts because of its lack of specificity, which can be construed as infinite suggestiveness” (Cook and Dibben, 2010:48-49). As a result, making sense of this music required, as Cook and Dibben identify, “...the reference points for valuing music move from the worldly, in particular ‘affect’, to the spiritual and universal (transcendence), while the musicological search for meaning moved from outside music to inside the music (formalism) (Cook and Dibben, 2010:48). Paradoxically, during the 19th century, ‘program music’, music specifically composed to tell a story, became popular with some composers eventually becoming a new genre of art music. As Cook and Dibben explain, this development again places the meaning of the music outside of the sound of the music itself (Cook and Dibben, 2010:49). This era also saw the growth of literature purporting to explain Western art music to the general public. Perhaps even in the 19th century abstract instrumental music without a voice part was ‘difficult’ for diverse listeners to understand without some external referent.

Just as contemporary concert listening, still (at least partially) grounded in the Romantic aesthetic of transcendence, it seems our approach to music analysis is still influenced to a large degree by Romantic ideas about music as an artform. The formalism which began in the 19th century dominated 20th century musicology. Most 20th century music theorists avoid issues of listener involvement by separating analysis from the experience of the music. Guck identifies this as an attempt to be more ‘objective’ (Guck, 1994a:217). The main way of dealing with this problem is to rely on the score as a metaphor for the music. As Cope discusses, despite scores only being archival documents they are usually considered to be the most reliable source of information on the music (Cope, 2008:5). However, they are considered reliable only because, as Treitler explains, our culture prioritises the visual over the aural while attributing objectivity to visual perception (Treitler, 2011:72). However, what happens in performance is not the score.

The score is interpreted by performers - thus what a listener hears is different from the score. Listeners use the same psychological mechanisms to make sense of music and to make sense of other experiences in everyday living. The lived experience and

perception of music is grounded in the everyday reality of the listener. Different listeners will hear different things in the same music, because different listeners focus on different features of the same available structures and materials of the music. As Nonken argues, all interpretations are available in the sound of the music as it is presented in performance (Nonken, 2008:287-288). Even though the score seems a fixed authoritative point of reference for the music, for performers it is simply a point of departure for interpretation inside which different performances will have different nuances. For example, as Barth explains at length, performers impose small tempo fluctuations on individual notes and over phrases to highlight significant points in the music (Barth, 1992). Some performers deliberately deviate from the score adding notes and repeating bars to extend introductions and/or bridge passages (Treitler, 2011:86-87). Hence, in many instances, what the listener hears is different from what is written down. It is the music being experienced, not the score.

Overlooking the aural impact of the music physically and mentally allows analysts such as Schenker, Reimann, Schoenberg in the early 20th century, and Babbitt, Forte and Lerdahl in the later 20th century, to ‘...abstract the music score in order to provide complete and self-sufficient explanations of music in exclusively structural terms’ (Cook and Dibben, 2010:51). Cope’s digital analysis of music scores (Cope, 2008:5) or the influential book *The Structure of Atonal Music* (Forte, 1973) are prime examples of analysis which, as Guck outlines, is “...written in the style of a technical report, which centres on the *physical* [her emphasis] attributes (and not the behaviour, or...the meaning) of the object of study” (Guck, 1994a:222). As Cook and Dibben observe “Although these theorists did not deny that music has affective powers, it was infinitely postponed for later consideration, while they focussed on structural analysis” (Cook and Dibben, 2010:51). The approach to music as an autonomous object obliterates listening in several different respects. As Guck argues, analysing music as score removes it from everything that makes that music affective and expressive (Guck, 1994a:217). In particular, score-based examinations rarely deal with music as a process that gives rise to a dynamic experience in which the listener’s responses vary as the music unfolds.

One exception is Meyer’s *Emotion and Meaning in Music* (Meyer, 1956). Meyer explains that music is not a static object but “...a process which gives rise to a

dynamic experience" (Meyer, 1956:54), but his work looks to the score for instances of where listeners might be affected. Similarly, Kerman acknowledges that listening is important, but relies on the score as the basis for his analytical remarks (Kerman, 1975:27). Greater priority is given to listening by Guck (1994a; 1994b; 1997; 2006), (Hirata, 1996), and Clarke (2005), who each actively include self-reflexive listening responses to inform their readings of individual Western art music scores.

Significantly, Clarke's 'ecological listening' moves beyond his own experience to theorise the importance of subjective responses of any listener when making sense of music, when he explains "...the experience of musical meaning is fundamentally - although not exclusively - a perceptual experience" (Clarke, 2005:8). Clarke justifies this claim because the perception of music allows appropriate response to events in the music, such as "...applauding after the final cadence" (Clarke, 2005:6-7). Clarke's supporting argument⁹ is small scale compared to my assertion that music can only be experienced perceptually¹⁰ because as humans this is one of the few ways we can experience every other object, tangible or intangible, that is external to our bodies. Moreover, listening responses go far beyond appropriate behaviour in concert halls.

Paradoxically, the ecological approach stands out as one of the few analytical methods which embraces the complete range of possible listening responses. As Nonken openly acknowledges "...the position and orientation of the perceiver determine what is perceived, how, and why" (Nonken, 2008:287). Clarke explains that 'ecological listening' recognises that different listeners can each focus on different aspects of the music, ranging from physical sources of sound, to structures within the music, to cultural meaning, to critical content (Clarke, 2005:47). As Cook and Dibben conclude, acceptance of this diversity of response implies that 'meaning' is no longer to be found only in the music but "...emerges from the interplay of the music and the listener with their own history, personal and critical influences" (Cook and Dibben, 2010:69). There are many positive aspects to 'ecological listening' as a method for making sense of music based on listening perceptions and cognitive events but, as Nonken argues, Clarke's method minimises his direct

⁹ Aside from the possibility that the end of the music can be signalled by other means in live performance, such as the ensemble stop playing at the same time, 'appropriate responses' assume 'insider' knowledge.

¹⁰ Unless credence is given to psychic abilities.

responses to the materials of the music as it unfolds over time (Nonken, 2008:288). Rather, ecological listening heavily relies on the ‘insider knowledge’ that comes with music training¹¹, and on the insider knowledge of academic analytical practices, without explicitly acknowledging that this is the case.

This is exemplified in Clarke’s demonstration analysis of a single movement of Beethoven’s *String Quartet (in A minor, opus 132)*¹². While attempting a method across a variety of genres is noteworthy, his analysis of Beethoven follows mainstream musicological conventions. Firstly, Clarke’s complete analysis of this music is grounded in academic musicological methods rather than his own direct listening responses. Specifically, as Clarke identifies, he uses a score-based semiotic method supplemented by other analytical perspectives (Clarke, 2005:158). Effectively this means that Clarke’s analysis is demonstrating that other musicological investigations into this piece of music also produce a range of interpretations. Secondly, analysing only a single movement of a whole piece of art music takes that movement out of its full music context, including any consideration of the title and the effect of knowing that this is only the first movement of a longer piece of music with a prescribed structure of movements. Ultimately, his descriptions of his thinking about possible perspectives for interpretive analysis, although ostensibly of the whole movement, are reduced to twenty bars of close analysis written in text (Clarke, 2005:175-187). Further, Clarke describes only the cognitive impact of groups of sounds, without drawing them together to find an overall idea which makes sense of his experience of the whole movement. Thirdly, Clarke (Clarke, 2005:177) reproduces the score in words by referring to minims and octaves in particular bars of the score, rather than referring to the sound of the music, nor without any explicit mention of actual time. Further, as Nonken

¹¹ Although it is important to recognise that it is hard, perhaps impossible, for those of us with music training to completely put ‘insider knowledge’ to one side when discussing music. Perhaps stepping outside disciplinary modes of language and argument is even more difficult when writing for an audience of trained musicians who may require conventional insider practices to legitimate new research methods.

¹² In order to demonstrate his method Clarke examines a single movement of a Beethoven, one piece of rock music (Jimi Hendrix’s live version of *Star Spangled Banner*), and two popular music songs (*Magdalena* by Frank Zappa and the Mothers of Invention, and *Taut* by Polly Jean Harvey and John Parish). Clarke sets out his intentions for using his method on different genres in his Introduction (Clarke, 2005:9-11), but only identifies the Beethoven String Quartet by name. Although the other music remains anonymous in Clarke’s Introduction, Jimi Hendrix “Star Spangled Banner” is the title of Chapter 2 and so first appears in the Table of Contents (Clarke, 2005:frontmatter, no page number), while the details of the two popular songs are mentioned for the first time in Clarke’s text on page 94.

identifies, Clarke mixes his moment by moment responses with his overall conceptual thinking about the music (Nonken, 2008:286), but there is no explicit mention of when the conceptual thinking took place. Consequently, Clarke's analysis seems far removed from a lived experience of listening to the music.

As Clarke's study demonstrates, ecological listening theoretically considers a broad range of responses and is potentially applicable to a range of Western music. However, as he acknowledges, his case studies are idiosyncratic and the methods are not replicated from one piece of music to the next (Clarke, 2005:9). Whether and why different music requires different approaches is not clear, however, all the music is analysed in text form.

Regarding the score as a metaphor for music, thus removes the music from the culture in which it is composed, and in which it is listened to. Therefore, regarding the score as the proper basis for analysing music does not fully recognise the importance of the complete sound of the music for its impact on how the music might make sense. Additionally, score-based approaches to music analysis and theory are generally unable to deal equitably with computer and other music which is not pitch-based in Western tuning systems. Finally, using a score means that it is easy to use terminology derived from music grammar/theory rules which can become divorced from the sound of the music¹³.

One of the complexities which bedevils music analysis is that nearly every sound event in a piece of music is a unique combination of specific features within various attributes. Scores only document timbre, pitch and rhythm, along with any expressive markings to inform the performer's interpretation. Typically, therefore, any other attributes of music are omitted from comprehensive analysis. Thus for simplicity, analysts tend to completely ignore attributes such as Texture, even though these attributes may have a significant impact on the listening experience. This can,

¹³ For example, Forte's application of set theory to note by note analysis of the scores of atonal music (Forte, 1973), could only be heard in the music by exceptional listeners even among trained musicians. Clarke's analysis tends to follow this trend, despite his assertions of open-mindedness. For instance, Clarke's worked example of listening to rock music begins with a score of *The Star Spangled Banner* with an additional symbol for moments of electronic distortion (Clarke, 2005:51, example 2.1). Then the text (Clarke, 2005:52-58) ostensibly describes the experience of listening to the sounds of the music, and mainly uses time points rather than bar numbers, but continually uses precise pitch names and other music theoretic terms such as cadence and tritone intervals.

as Darhlhaus acknowledges, make music analyses “...one-sided” (Darlhaus, 1983:vii). Obviously, as Nonken identifies, music not only includes “...harmony and rhythm but also such factors as silence, timbre [instrumentation], dynamic [amplitude], [event] density, texture, gestural and motivic figures, patterns, and audible processes of accretion and degradation (such as *crescendi* or *ritardandi*)” (Nonken, 2008:294). Gabrielsson and Lindstrom have also identified other attributes including tempo, timbre (meaning tone-colour, not instrument choice); harmonic character purely rated on dissonance and consonance; melodic range; melodic direction i.e. pitch contour; melodic motion e.g. stepwise or disjunct; tonality-atonality; articulation; amplitude envelope of individual tones (i.e. attack and decay); and musical form (Gabrielsson and Lindstrom, 2010:383-391). As Gabrielsson and Lindstrom explain, music is rarely exclusively determined by a single attribute, but is a function of many different attributes (Gabrielsson and Lindstrom, 2010:392). By omitting many of these attributes from analysis, it is difficult to provide proper evidence to explain how music might be expressive since what is experienced by listeners includes far more than these analysts explore.

Decisions about the timing of particular sound events are at the heart of the art and craft of composition. As Cope explains “Composers must know how to spin their works out slowly and creatively over large spans of musical time” (Cope, 2005:222). Composers can ‘recall’ previous events whether through direct reproduction of, or by replication of, or allusion to, significant elements of the original events, while simultaneously creating the conditions for future sound events to make sense. Ultimately, the composer brings the music to a close in a manner consistent with the ideas informing the music, so that “Works *end* not just *stop* [his emphasis]” (Cope, 2005:241). Composers somehow take different facets of time into account during the compositional process in order to design the work as a whole.

Often music analysts remove any sense of the composer as designer of the lived aural experience we know as music. Even though score-based analysis is primarily concerned with understanding the compositional structure, the composer as the agent of a time-based design is frequently invisible. Guck demonstrates how music analysts who work directly on understanding and interpreting compositional design delete the composer as the real agent who actively constructs the music (Guck, 1994a:222). Indeed, as Treitler identifies, some analysts assign agency to individual

notes and chords as if the sounds themselves make the decision to move up or down or resolve in complete independence from any input from the composer (Treitler, 2011:246). Guck argues this results from a standard convention in analysis whereby “...analysts convert acts [compositional decisions] into things [giving as an example that instead of writing] ‘the composer contracts the second phrase’, the analyst chooses to write ‘the second phrase is a contraction’ ” (Guck, 1994a:225). She concludes that this convention permits omitting precise detail on the activity, not only which notes were left in or out to make the second phrase a contraction of the first but, importantly, also removes the composer as an active agent who made decisions about the omissions needed to produce the contraction (Guck, 1994a:225). The analyst and score remain but the composer as designer of a time-based artform, as well as the sound of the music, has disappeared.

Using a score also leads to viewing the music as a static object outside of time, rather than as an unfolding process in which time is an important dimension. The multi-dimensional nature of music means its various parameters are constantly changing with respect to time and this often results in difficulties in identifying a static form. Spitzer argues that 19th century listeners regarded a piece of music as a timeless, isolated ‘object’, rather than an experience of a temporally unfolding process. Conceiving of music as a static object, grounded in our 3-D spatial-visual world, brings other associated comparisons. If music is structurally fixed like a sculpture, so the score becomes the ideal fixed visual representation of the music that can be “...subject to a variety of analytical interpretations but is still theorised as a self-regulating hierarchy of formal relations” (Spitzer, 2004:130). Thus, music theory articulates various forms of music abstracted from actual time durations. For instance, sonata form is defined by three main sections: exposition, development and recapitulation (Webster, n.d.). The time dimension, one of the most significant aspects of music, is not explicitly articulated, or is referenced in bar numbers. As we know, bar lines in music represent, and document, meter and thus refer to the rhythmic content of the music. Bar numbers hint at, but do not directly measure, elapsed time. Further, visual art works are simply present as a whole at any moment, while music takes place through time, so the sculptural metaphor means that music analysts depict time as having spatial characteristics even though “...its physical laws seem different. Musical space is both more malleable and more

inclined to change its characteristics without warning than is physical space” (Guck, 1994a:225). Thus, real time seems to have disappeared, which is a significant omission because music is time-based, ephemeral, intangible and abstract, which makes it unique among art forms.

Audiences will never see music, it does not exist in visual form. However, descriptions of music are often related to genres in visual arts such as representational, still life, portrait, abstract, landscape, sculpture, experimental, or conceptual. For example, sonic art performances have been described as “...wide ranging landscapes...” (cited in liner notes for Rolnick, 1985), while David Jones has titled one of his works *Still Life Dancing* (Jones, 1989). Concepts derived from the visual arts are also used to generalise the processes that make music from sound. For example, the term ‘soundscape’ is derived from the visual art notion of ‘landscape’ (Wishart, 1996:5), while Claude Risset, a pioneering French computer music composer, refers to the act of creating new sounds by using digital tools as ‘sculpting’ sound (Risset, n.d.). Yet the analogy of music with visual art brings analytical focus on structural coherence, through in-depth technical analysis of the score to provide insights into compositional structures and form. While structural analysis helps to make sense of the compositional process, as Walser observes, the practice of using terminology from visual art to describe music is not useful because visual art is tangible and generally static (Walser, 2003:25). Structural analysis is a secondary procedure that for some listeners may form part of, but is distinct from, the actual experience of listening and responding to the sound of the music as it unfolds over time.

Explicitly including time consciously transmits one of the significant qualities of music as an artform. As Moore discusses “...music is a temporal art, its proper study necessarily includes a method for capturing, representing, and interpreting information about successive moments in time” (Moore, 1990:3-4). Importantly, the now invisible passing of time and the associated evolution of sonic materials make a real contribution to the impact of any music on the listener (Juslin and Sloboda, 2001:15). Sense-making occurs in real time as part of the listening experience, as well as after the music has ended. Spitzer suggests that music theorists and other

listeners map¹⁴ from physical experience to a mental concept of the structure as their listening response (Spitzer, 2004:4). However, this is debatable because, as Rowe identifies, listeners cannot always consciously perceive the underlying structures (Rowe, 1993:204). Even if listeners are able to perceive the underlying structure, experimental research shows that most commonly, listener perception of emotional expressiveness is mainly influenced by attributes such as tempo within phrases or sections of the music rather than by the overall form (Gabrielsson and Lindstrom, 2010:384). Even though these results may not be generalisable to the more intellectual ideas projected through avant-garde music, the results suggest that in general listeners attempt to make sense of the surface of the music, rather than listening for compositional processes and structures that have given rise to this surface. The surface of the music is where listeners initially locate appreciation of the music and make sense of their listening experience.

Semiotics is a different approach to understanding meaning in music that investigates how specific music events infer specific but generally accepted meanings for listeners from the culture in which the music is located. For instance, according to Clarke (2005:159), in earlier centuries listeners commonly identified some elements of Western art music with other human activities. Those listeners would know that horns signify hunting, and certain rhythms signify particular dance types. Yet these would only be understood by fox-hunting British listeners and those somehow familiar with particular dance styles. However, as Naomi Cumming observes semiotics is not “...a closed discipline with a fixed set of methodologies, but a wide-ranging set of interpretative projects...”, although many investigators seek to establish ‘codes’ of meaning in particular styles of music (Cumming, n.d.). For instance, Cummings asserts that the first important publication by Wilson Coker was in 1972¹⁵, in which he sought to find some relationship between his formalist analysis of structures in the score to extra-musical ideas. This was followed by Jean-

¹⁴ ‘Map’ is a term used in mathematics to denote a direct correspondence between the location of points in one domain and their location in another, just as a map of Australia corresponds to the physical features to be found in the real-world landscape. The Quick Reference Guide to Terms provides definitions of many technical terms like ‘map’.

¹⁵ Coker, Wilson (1972) *Music and Meaning: a theoretical introduction to musical aesthetics*. Free Press, New York.

Jacques Nattiez in 1975 (translated into English in 1990)¹⁶ who investigated semiotics in Western art music using a formalist score-based analysis on the internal relationships in the melodic contours of a piece of music which excludes composer and listener. Curry (2013:179) asserts that Philip Tagg¹⁷ was one of the first to challenge formalism in 1979, using TV title track music to create a semiotic theory of how qualities of music refer to meaning outside of music which can be readily and commonly identified by many listeners within the same culture (for him, the urban West). Tagg later tested his theory on 604 student listeners including some adults, regarding the broad ideas (e.g. a lush green valley) portrayed by excerpts of 10 TV title tunes (played without images) (Tagg, 2012:167). Thus Tagg's semiotic theory of the meaning of music builds a bridge between diverse listeners' knowledge and the meaning they give to music in a formalised way, by recognising that at least parts of listening responses are intersubjective and are guided by the music in question, the particular listener being studied, and which cultural and historical circumstances surround the listening experience (Tagg, 2012:200). However, the bridges are somewhat tenuous because semioticians use everyday words such as 'icon' in special ways (which are confusing to read and comprehend). For example, Curry's (2013:177-178) own definitional work declares that most people think of an 'icon' as an object so culturally significant that it has become part of everyday discourse (his example is Andy Warhol's image of Marilyn Munroe). However, Curry defines a semiotic icon as something that realistically resembles the thing it refers to: i.e. a picture can be 'iconic' if it realistically represents the actual object (as opposed to symbolic where symbol shape is different from the object it represents). However, to my way of thinking, 'icon' can also be interpreted in the 21st century as a medieval religious painting in a place of worship, or more frequently as a visual symbol and portal for an app on a digital tablet. Both of these 21st century images are quite stylised and symbolic, and both seem to have a meaning other than either of the two put forward by Curry.

¹⁶ Nattiez, Jean (1990) *Music and Discourse: Toward a Semiology of Music* (trans. Carolyn Abbate). Princeton University Press, Princeton, NJ.

¹⁷ Tagg, Philip (1979) "Kojak-50 seconds of television music: toward the analysis of affect in popular music." PhD Thesis, Göteborgs University.

However, not only is the terminology obscure, but we can see evidence for Samuels' recent observation on the state of semiotics in music, that there is still no single definition of what constitutes a 'sign' in music and, secondly, to what these signs refer (Samuels, n.d.). Semiotic theories have not yet reached a systematic consistent state of being able to move from specific attributes and events in the sound of music without text to the external meanings these sounds might hold for a listener. The state of semiotic theory reflects the underlying state of musicological research.

Musicologists tend to use different theoretical frameworks for analysing specific types of music, even avant-garde music. For instance, Straus asserts that Forte applies Schenkerian-style analytical methodologies only to music from Bach to Brahms, and similarly Forte applies his own theory of motivic relations only on chromatic music of late 19th century, such as that composed by Mahler. Straus continues that Forte only studies pitch class theory with canonical composers of the first half of the 20th century such as Berg, and Webern, and Bartok, but not Cage and late 20th century composers (Straus, 2015:3). It is challenging to investigate the complexity of music as an intangible time-based artform, but as Landy suggests, "Perhaps the need that seems greatest at this point...[is] the search for those best-practice models that are applicable beyond the individual work" (Landy, 2015:6).

As discussed previously, making sense of any unfamiliar music that relies on sound alone to convey meaning in performance has not been an easy task, ever since the abstraction of Western art music from functional support for text in the nineteenth century. In an effort to resolve this problem, promoters and advocates of Western music have developed several framing devices to help diverse listeners make sense of unfamiliar music.

2.3 Producers' Framing Devices for Making Sense of Music

Making sense of conventional Western instrumental music is problematic because, as previously discussed, music without text can only provide abstract non-unique pointers to extra-musical events. Yet, as Meyer argues, people make conscious and unconscious mental and physical adjustments before concert-style listening to prepare themselves for the aural experience to come. Meyer suggests that listeners approach concert-style listening influenced by many factors, such as their beliefs

about 'aesthetic' experiences in general, and music experiences in particular; previously acquired experience and knowledge about the specific music; and information gathered about this listening occasion (Meyer, 1956:73). However, a chorus of academics claims that the difficulties of making sense of Western art music can only be resolved by training in what can be called 'insider practice'. Budd suggests that "...the ability to hear the interconnectedness of the sounds which are in [any] music...requires education" (Budd, 1985:x). Whalley suggests a little more gracefully that "The quality of listening can depend on... the knowledge of music brought to the situation" (Whalley, 2000b:150), while Babbitt spells out the required knowledge fully in his suggestion that listeners, particularly for avant-garde music, need a professional standard of musicianship, with its requisite focussed, lengthy training in aural perception, music analysis and music history (Babbitt, 1958). This suggests that most listeners would need to spend considerable time on background study before listening. This requires listeners to have the inclination and the financial resources to obtain these resources.

As previously noted, in the 19th century, instrumental music without text had become the dominant paradigm in Western art music. However, the increasing autonomy of music from text has meant increasing difficulty in universal interpretation of the music. As Simeone demonstrates, the interpretation of unfamiliar instrumental music for diverse listeners has been in place at least since the early 18th century (Simeone, n.d.), sometimes in print, sometimes in public lectures or pre-concert talks. In particular, Cook and Dibben's assessment is that Beethoven's eccentricities in his later music contributed to significant growth in written commentaries such as program notes¹⁸ and music appreciation texts in the 19th century (Cook and Dibben, 2010:49). Primarily the evidence for the efficacy of these framing devices is anecdotal; however, in the last 30 years there has been some more substantial investigation.

The enjoyment of Western art music for trained and untrained listeners is enhanced by extra-musical information. For example, Payne has demonstrated that extra-musical ideas play a significant role in enjoyment for trained musicians (Payne,

¹⁸ As with many other words, 'program' is spelled differently by users of Americans and British English. I have chosen the American variant in this instance because it is shorter and less fussy (not fuzzy!).

1973:177). Halpern and Weale each independently demonstrate that the enjoyment and understanding of unfamiliar and unusual music by listeners without formal music education is significantly enhanced by ‘education’ in historical aspects of music, the circumstances surrounding its composition, composer biographical details, and specific intentions for this particular music (Halpern, 1992:45; Weale, 2006:196). As Simeone documents, the program note is now an important part of the concert-going experience (Simeone, n.d.). 20th century program notes continue to explore what particular instrumental works might mean by looking outside of the music, but also contain large amounts of technical information about the music being performed. As Halpern explains, any person who takes an active interest in Western art music is constantly subjected to technical analytical writing in magazine articles and program notes whether on CD covers or in concert programs (Halpern, 1992:45). As Halpern illustrates, commentaries on popular music do not include any music analysis or technical information regarding the music, but rather stories about the musicians or the music (Halpern, 1992:45). Halpern argues that because listeners without music training “...value music through an understanding of its human origins” (Halpern, 1992:42), modern program notes for Western art music would be more useful if they contained information regarding the ideas which might have influenced the compositional design (Halpern, 1992:45).

Another common method of delivering information to listeners is the pre-concert talk. Payne’s research shows that trained listeners’ response to unfamiliar music is impacted by an “awareness of, and interest in, various [technical] aspects of music” (Payne, 1973:177). However, Halpern and other researchers have also demonstrated that music appreciation by untrained listeners is not significantly affected by providing technical information immediately prior to listening (Halpern, 1992:40). For example, Lindstrom, Camurri et al., concluded that diverse listeners found a pre-concert explanation of the technology through which the live soloist would influence computerised playback of music only somewhat useful to sit through (Lindstrom, Camurri et al., 2005:73-74). As Halpern explains, although technical aspects are interesting to a trained musician, this type of information is “...often perceived as wordy, confusing, and dull, and...[does] little to enhance non-musicians’ appreciation of music” (Halpern, 1992:45). As Pitts concludes, finding the right tone is important (Pitts, 2005:265). Additionally, as Pitts documents, pre-

concert talks which assume considerable knowledge of the repertoire through references to other music in other concerts and venues does not welcome newcomers to art music (Pitts, 2005:265). The apparently contextual information is meaningless to listeners unfamiliar with the repertoire, and may lead newcomers to feel a sense of being out of place and not belonging to the 'in-crowd'. By contrast, Pitts demonstrates that audience members at a chamber music festival valued introductory talks which were enthusiastic about the music, informal and conversational in style by containing jokes and asides (Pitts, 2005:264). The talks used a minimum of technical language but included snippets about health, friendship, what made the composer write the music, and rehearsal experiences (Pitts, 2005:265). Again, 'uneducated' listeners value information about music which relates to ideas rather than technical details about the music or performances.

However, each piece of music is given a title as a shorthand way of referring to the music, which also provides information to the listener. Titles prepare the audience to make sense of the sound of the music. Appropriate and adequate titles succinctly frame the listening experience. Weale demonstrates that the title can signal important information about avant-garde music by stimulating listener conjectures regarding ideas in the music they are about to hear (Weale, 2006:194). Yet Farnan suggests that a title is only important for interpreting avant-garde music because that music is not simply enjoyable in the same way as conventional acoustic music (Farnan, 2014). However, as Tagg discusses, the title of the music is important in framing how any music is to be perceived. Tagg asserts that titles are designed to influence the meaning listeners derive from the music no matter the circumstances of listening (Tagg, 2012:78, 113). For instance, formal titles for conventional music, such as *Variations for Piano in Eb Major*, provide a lot of information about a piece of music without going into specific details.

These formal titles summarise the sound source and textural world (the number and relationship of the instruments), the large scale form (the likely number, form and character of movements) as well as its likely small scale content, such as particular harmonic progressions. Yet these formal titles of acoustic music cannot detail every individual approach to that form, or the how the composer uses the named sonic materials in this specific work. Nonetheless, for those who can understand the terminology, the generic labels go beyond the production technology to also give

details about the musical product. Because the formal titles of music often assume ‘insider knowledge’ some pieces of music have been given less formal names, by either composer or publisher, referring to relevant thematic material within the music (Randel, 1978:160). Other music, such as Haydn’s *Symphony no 94 in G major* or *Symphony no 101 in D major* attracted names from listeners like ‘Surprise’ or ‘Clock’ respectively, due to characteristics within the music experienced while listening (Randel, 1978:107,492)¹⁹. Using descriptive words as labels for individual pieces of music is a very human activity directed towards providing a framework for making sense of the music. These informal names, whether given by composer, publisher or audience, enhance the technical details in the formal title with labels that relate to human concerns and interests.

Summation

Music is a multi-dimensional, abstract, ephemeral, intangible, art form which is hard to concretise when providing evidence for assertions. As Guck argues, music analysis struggles with the “...immaterial, enveloping, evanescent nature of musical sounds. They are all around us and most intensely within us, but not, except as represented in scores, in an immutable form that we can examine...the musical work lies...just out of reach...after the fact...catch as catch can...it reflects what the interaction with music is like”(Guck, 1994a:228). In any music, the composer decides what aspects of the materials to highlight and how to emphasise those aspects to elucidate an idea. As mentioned in Section 2.1 (see pp. 63-65 above) ideas range from the compositional process itself, such as the workings of generative algorithms; are concerned with thoughts and feelings; or provide a listening experience. For example, some music is rhythmically active and vibrant, whereas other music will focus on the linear aspects of melody. A Bach fugue showcases the interaction of rigorously structured thematic materials and contrapuntal processes, focusing on the interweaving of polyphonic lines. During

¹⁹ Sipe reports that the English version of the score of Beethoven’s *Eroica* Symphony was printed with an incorrect subtitle indicating that it was written to commemorate the death of a great man. Sipe explains that as a result, critics attending performances in both in England and France reported that the music was wrong as the symphony should have ended with a funeral march. Instead it ends with a minuet (a lively formal dance). Because of the incorrect subtitle, this light upbeat ending was regarded as completely inappropriate (Sipe, 1998:60).

Cage's 4'33", a three movement piece of music in which the solo pianist is always *tacet*²⁰, listeners are given an opportunity to find themselves aware of the environmental sounds that inevitably break the silence (Pritchett, Kuhn et al., n.d.). By contrast, Reich acknowledges that his music composed specifically to showcase compositional processes (Reich, 1968:34) effectively produces a listening focus on the nuance of sound (Reich, 1968:35). Composers seek to provide a vast range of different experiences to listeners.

The 'science' method applied in experimental psychology is designed to provide concrete evidence to support hypotheses about human behaviour. Systematic musicologists address problems with similar 'scientific' methods. Psychologists have been using statistically validated experimental procedures to examine listening responses but are primarily concerned with the perception and stimulation of emotion, even though there is still significant debate among empirical researchers about the actual and specific nature of individual listening responses to music (Juslin and Sloboda, 2010:5-6). For instance, Friberg identifies that emotional content can be significant in the enjoyment and understanding of music for some people (Friberg, 2006:37), while Juslin and Vastfjall discuss the possibility that, "... much of what makes musical experiences "special" are truly non-emotional aspects, such as the conscious perception of musical form and its dynamic changes over time" (Juslin and Vastfjall, 2008b:611). However, existing statistical research methods also lack 'ecological validity' because the experiments are rarely conducted using real music in real performances in realistic listening situations in real time.

A listener has the potential to turn any aural experience of a stream of sound into music given sufficient information to frame the listening experience. Each listener has access to different amounts of background information to inform their listening, particularly when it comes to avant-garde music with its individualistic qualities. Any listener brings some general knowledge, life experience, and insight to the listening experience, as well as general knowledge of music and social history, or specific detailed research from musicologists on the compositional context. Trained listeners have more background knowledge of technical aspects of music, and have

²⁰ The performer is completely quiet, not producing any sound on their instrument. This term is most frequently used in scores to indicate that particular players are to remain silent while others continue.

greater capacity to access technical information should they be interested. Insights into ideas including recall of prior knowledge about things such as composer, style of music, or presentation methods can be prompted by cues within the listening environment, and other immediately accessible information. Indeed, concert-style listening can be framed by information from many sources. These sources include marketing information and program notes, as well as the formal title (the title given the music by the composer) and informal title (the title given the music by initial audiences or printers of the music appealing to consumers). Each information source gives some insight into potential ideas the composer is expressing through this music, even though there is no guarantee that these texts accurately capture either composer's intention or describe any ideas individual listeners perceive in the music. Most people listen to music for the experience of listening, whether or not they are informed by the study of background information.

What we need is a method for making sense of music which can work with unusual sounds, forms and presentation methods but which recognises that different listeners have different ways of making sense of the sound of the music. We need a process that is accessible, uses personal responses, is time-based and transparent, and works in a life-like concert-style listening situation. What we need is listener driven music analysis for the 21st century that recognises that real-time listening to music engenders a broad range of ideas including, but not only, emotion, while documenting the perceived technical aspects of music that contributes to those ideas. Recognising the continuum of musicological discourse, the way the music might make sense can arise from particularities inside the music or from within the listener because of external referents stimulated by the music.

Chapter 3. Fuzzy Logic and Music

My thesis is that fuzzy logic is a useful way to work with information that includes technical and cognitive responses derived from an individual experience of listening to music. Fuzzy logic¹ informs the overall design of the new analytical method but the actual application occurs principally in converting the qualitative listening observations into fuzzified data. The key contribution to knowledge made in this thesis is this practical detailed application of fuzzy logic principles to produce an informative visual representation of the qualitative experience of listening within a new method of music analysis. The first part (Section 3.1) of this chapter sets out the reasons fuzzy logic is useful for investigating music and for reporting a single listener's personal responses.

My focus on individual response simply follows the cultural norms of the Romantic movement which, as Constant Lambert observes, is "...marked by its insistence on the individual as opposed to the crowd" (Lambert, 1985:144). Despite the 20th century challenges to Romantic music, this emphasis on individualism remains a hallmark of both avant-garde music and fuzzy logic research. As Darhlhaus argues, not only is it impossible to be completely objective, but both objective and subjective content are necessary when assessing individual pieces of music, because judgement needs objective content, yet objectivity needs the "...substance supplied by emotion" (Darlhaus, 1983:4). As discussed above (see pp. 63-65) the focus on emotion as the only subjective response to music is too narrow, but fuzzy logic provides a useful way to characterise the technical and cognitive responses to listening to a piece of music enables the incorporation of both types of information.

The present chapter continues with a review of existing research into a range of music problems using fuzzy logic. Clearly, I am not the only one who thinks that fuzzy logic has potential for representing music. This literature is scattered among journals in computer science and engineering, rarely in music. Collating this

¹ This present chapter is concerned with setting out the rationale for the suitability of Fuzzy Logic for listener-oriented music analysis, rather than the mathematical underpinning and the mechanics of Fuzzy Logic in mathematical applications. However, a summary of Fuzzy Logic theory along with examples of existing practical applications is provided in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see pp. 449-458).

literature into a coherent body of work is one contribution of this thesis. The review shows that no existing research involves the practical application of fuzzy logic to make sense of music from a listener's perspective, although some recent developments foreshadow my application of fuzzy logic research written up in this thesis. This literature shows that fuzzy logic is usually only applied to one part of a larger problem, but the whole of the problem is described as being solved by using fuzzy logic. This allows me the same leeway in describing my own research.

My aim is to find ways to make sense of the music using the experience of listening for ideas as the sounds of the music unfold. A new method is most useful if it can be applied to computer music and conventional instrumental music in a realistic listening situation. The method needs to be able to incorporate a broad range of responses as they develop over the course of the music. Although the older existing methods for understanding music should not be completely discounted, it seems sensible to explore contemporary approaches to knowledge building and problem solving for new tools relevant to making sense of music without text. As Kostek identifies, the relatively new field of 'artificial intelligence' offers new insights and methods for investigating the subtleties of the music experience (Kostek, 1999:54).

Computer engineers developed artificial intelligence during the 20th century to enable machines to operate on complex problems with minimal human intervention. Artificial intelligence simulates human thinking and problem solving. Because computer programmers had a new need to formalise human thinking: mental activities had to be conceptualised, broken down, and articulated at every step of a problem-solving process. As a result, artificial intelligence researchers give much thought to conceptualising human cognition, learning and intelligence, and how these higher level human functions work in practical terms. Fuzzy logic² was conceived in the latter part of the 20th century as a way of emulating human thought processes when solving problems. I argue that applying fuzzy logic principles to convert qualitative listening observations into fuzzified data, then mapped into visual representations of the multi-dimensionality of a single personal

² An overview of fuzzy logic theory and its application in commercial contexts are presented in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see pp. 453-462).

experience of a piece of music, enables comprehensive substantiation of why and how an abductive idea makes sense of that music.

Then Section 3.3 (see pp. 112-113 below) moves to a discussion of the suitability of fuzzy logic for listener-oriented music analysis, in principle to inform the method as a whole, and specifically to describe and classify elements of the music experience.

The chapter concludes by investigating existing applications of fuzzy logic to problems in music across performance, composition and music analysis.

Engineering and computer science, specifically in the field of artificial intelligence, are the disciplines that dominate the research literature on fuzzy logic theory and applications. Unsurprisingly, most applications of fuzzy logic to music are computer programs, designed to automate specific tasks. This review shows there is no typical application of fuzzy logic to music problems, nor typical research problems in which fuzzy logic is applied. However, several researchers foreshadow the practical system of music analysis that is developed and evaluated in the remainder of this thesis.

3.1 Value of Using Fuzzy Logic

The underlying principles of fuzzy logic theory³ provide a *prima facie* case for its application to music analysis and interpretation. Fuzzy logic has the capacity to incorporate the diverse information inputs required for the new analytical method. This section explains why fuzzy logic principles are useful in describing and categorising the technical elements of music individually and collectively, and the cognitive responses that contribute to specific listening experiences. Importantly,

³ Fuzzy logic is a new mathematical method developed in the late 20th century. The term ‘fuzzy logic’ is a confusing conflation of two new distinct, though related, mathematical ideas. First, the theory of fuzzy sets adds two new concepts to conventional set theory. The second implication of the term ‘fuzzy logic’ are those variations in conventional mathematical logic that enable fuzzy sets to be manipulated when solving problems. The historical and mathematical evolution of fuzzy logic from the mathematics of conventional set theory is explained in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see Section F.1, pp. 449 451).

fuzzy logic aims to simulate human thinking when problem-solving⁴. Its most striking aspect is its ability to contain and work with imprecise, ‘vague’ or uncertain concepts. Fuzzy logic is designed to represent human knowledge in a meaningful way to enable decision making in uncertain, imprecise or incompletely known environments (Zadeh, 1998:24). Fuzzy logic is transparently meaningful because fuzzy feature sets are labelled with words from natural language⁵ (Zadeh, 1998:24). Using words to describe objects is useful for several reasons.

Linguistic variables are useful for communicating concepts and knowledge with human beings. As Yen discusses, associating a fuzzy set with a linguistically meaningful term offers two important benefits. First, the association makes it easier for human experts to express their knowledge using these linguistic terms. Second, the knowledge expressed using linguistic terms is easily comprehensible (Yen, n.d.:4-5). For instance, use of linguistic variables, such as “deafening” rather than a numerical “120dB”, conveys more about the quality of the sound to most people. Although 120dB is precise, describing an amplitude this way has limited useful meaning except to audiologists.

Applying linguistic variables results in straightforward, intuitively correct and transparent modelling, especially when compared with complex abstracted mathematical symbols and formulae. As Kostek explains, using natural language descriptors allows a broad range of users to understand the way relationships between real world variables have been modelled (Kostek, 1999:230). Other researchers observe that using natural language means that some combinations of words are already meaningful to humans, so it follows that modelling using these particular data sets produces intelligible results (Efstathiou, 1984:317; Elsea, 1995).

⁴ The field of artificial intelligence incorporates different concepts on how best to emulate human thinking, such as fuzzy logic, neural networks, and Bayesian systems. Fuzzy logic is designed to emulate problem-solving processes to perform concrete tasks in the physical world. By contrast, neural networks are based on theories of brain structure to enable machines to learn and classify objects accurately, while Bayesian inference systems use probability models to decide which single result is most likely to be correct, given a prescribed set of fixed choices.

⁵ ‘Natural language’ and ‘linguistic variables’ are strange terms for researchers in the humanities who are daily concerned with use of language in diverse ways. The need for and use of these terms in fuzzy logic reflects its background as a product of computer science. What these terms signify is the language that we humans use when thinking and to communicate with each other. Computer scientists also use symbolic languages such as machine languages based on bits and bytes, or complex algebraic formulae particularly in neural networks, and probability based calculators.

Additionally, Efstathiou identifies that natural language descriptors often inherently provide ordinal information⁶. This is enough for problems to be solved without the need for mathematical abstraction (Efstathiou, 1984:313). This aspect of fuzzy logic means that complete decision-making processes using fuzzy logic principles are relatively comprehensible to their users, not simply the researchers.

Gaines and Kohout identify that theoretical development of fuzzy systems is designed to emulate human linguistic reasoning with imprecise concepts (Gaines and Kohout, 1977:19). It seems that by using linguistic variables, fuzzy logic can provide a readily intelligible bridge between human thinking processes and rule-based automated systems.

Different methods can be used to construct fuzzy logic models. For instance, Fuzzy ART automated systems designed by Carpenter, Grossberg et al. (Carpenter, Grossberg et al., 1991a) learn from repeated experience to enable classification of objects with specific fixed qualities that might embrace a range of values. Systems with a range of variable inputs, for example such as that devised by Mamdani, Ostergaard et al, for running a steam engine in different environments (Mamdani, Ostergaard et al., 1984), rely on the experience of experts in the field. As Stotts and Kleiner discuss, all fuzzy systems are tested for accuracy by fine-tuning the rules until the system produces results consistent with real world behaviours (Stotts and Kleiner, 1995:14).

Because fuzzy logic is framed in natural language concepts, this suits writing and thinking about music very well. Music is an excellent domain in which to apply fuzzy logic. Music is time dependent; an abstract art form; it includes a combination of emotional and intellectual qualities in varying degree; and its terminology is imprecise. Music can be 'known' in many ways: through listening in a variety of focussed (such as concert listening, performing and composing) and unfocussed situations (such as while cooking or dancing). As Moore explains, this 'knowing' cannot always be communicated verbally. However, "...words are indispensable in creating meaning for ourselves out of the music to which we listen" (Moore, 2003:1).

⁶ See the Quick Reference Guide: Glossary of Terms, p. xxvi for definitional information on this mathematical term.

Discussion about music, music theory and analysis, including its techniques, its description, critiques and instructions to performers, are usually in words.

Particularly, music theory uses words to convey ideas that are not precisely defined in specific instances. For example, what are the features that define 'concerto'? Can a piece of music for solo instrument accompanied by a group of others be categorised as a concerto? How does the existence of this piece with its individual characteristics affect the category 'concerto' itself? This can often be answered intuitively, but to specify exactly why and how can be complex. Typical analytical decisions about how to classify a note, a chord, a sound, a section, or even a whole piece of music, are justified on the basis of the relationships of some musical elements while ignoring those elements or relationships that don't fit. Most music events have multiple descriptions, making them very difficult to classify. In such instances, the useful aspect of fuzzy logic is its principle of inclusivity. For example, a specific aural event, according to conventional thinking, can only be classified as either one or other chord type whereas fuzzy logic takes the idea that something can hold simultaneous truths to some degree. In fuzzy classification, the aural event can be classified as belonging to both 'E major' and 'E minor'⁷.

Fuzzy logic is useful for describing and categorising music events because of five principles on which fuzzy logic is grounded:

1. it works with subjective opinions regarding the importance of attributes and their interactions, and allows very different qualities to be simultaneously included in the depiction of objects
2. it addresses vagueness in data and uncertainty in classification
3. it works with as little or as much data is available
4. it works with small sample sizes
5. it compresses original data to make it manageable and useful in further calculations.

⁷ The ambiguous harmonies in the Prelude to *Tristan und Isolde*, an opera composed by Richard Wagner, first performed in 1865 (Millington) is such a well-known example that it can be found with its own subject entry in Groves Music Online, as the "Tristan" chord. This article goes onto describe how the actual chord can be classified as either "...an augmented (French) 6th chord...[or] an added 6th chord in first inversion with chromatic alterations..." ("Tristan' Chord").

Overall, my thesis is concerned with schema and rationale for how a ‘smart’ system of listener-oriented music analysis can be conceptualised, as a necessary part of developing an automated system in the future. This section explains these principles of fuzzy logic, all of which make Fuzzy Logic suitable for listener-oriented music analysis. The practical application of these fuzzy logic principles in my analytical method is detailed in Chapter 5. *Fuzzy IDEAS: Applying Fuzzy Logic to Analyse Avant-Garde Music* (see pp. 153-197 below).

Principle 1: subjective opinions are valid

Fuzzy logic can provide a generalised transparent approach to the technical aspects of music while incorporating the subjective responses during listening. Kostek has demonstrated that fuzzy logic is a useful and valid means of determining the relationship between subjective evaluation of overall audio quality and technical aspects of the sound that contribute to that assessment (Kostek, 1999:166). More specifically, Kostek has also demonstrated that fuzzy logic can be used to produce valid evaluations by cumulatively combining subjective listening assessments about each different technical aspect of audio quality (Kostek, 1999:230). The research was a purely technical assessment of audio quality by a small panel of sound engineers, rather than the impact of music on an individual listener. However, her work shows the utility of fuzzy logic across various aspects of experimental design relevant to music.

Another important aspect of fuzzy logic is the possibility of using either experts, or non-experts to provide input to the system. This human perspective on aspects of the real-world problem includes designating which elements of the situation are significant and the way these elements interact with each other to produce an outcome. This permits the listener to be the expert on their own listening experience, as they determine the important aspects of the music while listening, and it allows the analyst to be expert in naming and analysing features of music. For example, Lambert identifies the two preludes in Stravinsky’s *The Rite of Spring* as impressionist in nature because they lack clear a clear textural definition and rely solely on colour (Lambert, 1985:48). Similarly, potential elements, which a listener may perceive in the music, can come from any areas of interest: philosophy, found

sound, cultural studies, feminism, historical antecedents, other music analysis, neuroscience, psycho-acoustics, performance practice, or notation practice.

Principle 2: vagueness in data and uncertainty in classification

Music is an ephemeral, intangible, multi-dimensional, abstract art form. Music is a personal experience hard to articulate into language and nearly impossible to measure in absolute terms, either qualitatively or quantitatively. Further, as Guck critiques, individual analysts use different technical terms to describe exactly the same note combinations, which implies that these entities have different aural natures (Guck, 1994a:226 note 21). Because fuzzy logic is inclusive of all responses, its use for classification purposes encourages music to be technically defined in sufficiently broad terms to include all genres of music. Common musical notation is an attempt at precision, but even some elements of notation are vaguely defined. While words themselves have relative meaning there is no absolute meaning of 'loud' or 'cantabile' or $<$ or $\curvearrowright$. Fuzzy logic has been formulated specifically to deal with the imprecision and 'vagueness' which is present when using natural language descriptors. Fuzzy logic can work with features that are precisely measurable, even though other features might be fuzzy (Efstathiou, 1984:313). For example, it is possible to work with precisely defined tempos such as MM ♩ = 60 and amplitudes such as 'loud' and 'soft'.

Fuzzy logic systems can be represented and summarised in a variety of different ways, such as graphs of functions, matrices of numbers, Venn diagrams, or equations. However, they all have the same underlying methods and principles. The essential underlying premise is that some specific object is usually hard to classify in the 'either-or' system of science, binary computing and probability theory, and that binary classification requires 'quantisation' or rounding off to the nearest unit. In this process, information is lost and complex things are over-simplified. Music theory and analysis are couched in terminology that is imprecise.

Principle 3: only requires modelling of known factors, rather than the whole system

Non-linear systems cannot be mathematically described as the sum of their components. This behaviour can be observed across a variety of disciplines, including biology and economics as well as physics ('Non Linear', "Non Linear", 2007). There are, however, many aspects of fuzzy logic that make it a very useful method for unpicking some of these knots. As noted previously, Kostek demonstrates that fuzzy logic permits overall assessment based on a variety of different attributes, combined to produce a universal result (Kostek, 1999:230). Cordon, Herrera et al., conclude that fuzzy logic is good for modelling non-linear relationships particularly when presented with the problem of how to represent "...processes that are imprecisely described, or are controlled by humans without recourse to mathematical models, algorithms or a deep understanding of the physical processes involved" (Cordon, Herrera et al., 1996:136). Fuzzy logic is good for modelling non-linear systems, because little previous knowledge of the original system is required.

Music is technically a non-linear system because the imaginative outcome of listening to music is often more than the technical elements in the music. Indeed, what is the role of timbre, attack, duration, decay, articulation, spatialisation, register, texture, voicing, entries and timing, rhythm, tempo or metre? What do musical form, structure, or process contribute? In fact, it is often the means and details of the interactions between the distinct elements that significantly influence the effectiveness of the whole work.

Principle 4: works with small sample sizes

"The principal objective of fuzzy logic is the formalisation of decision making in environments of... incompleteness of information, partial knowledge of truth and class membership" (Zadeh, 2008). As Kostek demonstrates, fuzzy logic enables testing with a number of samples that are too small to be valid for statistical analysis; as well as incomplete or inconsistent data; or where summary description

based on statistical analysis is not useful⁸ (Kostek, 1999:230). The number of features being explored can increase as necessary to adequately describe the complexity of the object under examination.

Principle 5: compresses data but still retains useful information

Fuzzy IDEAS as an analytical engine is necessarily reductive. Analysis is useful precisely because it strips away information and therefore, by definition, as Walser identifies, analysis “...reduces and abstracts to show particular relationships more clearly” (Walser, 2003:25). Software engineers describe the purpose of analysis as finding a “...minimal data representation of the [music] signal”. In other words, the analysis task, which consists of describing a music signal, is equivalent to a *structured compression task* [his emphasis] (Jehan, 2005:24). Fuzzy logic is a particularly useful form of data compression because it maintains precision through the classification method. This enables even complex manipulations of the fuzzy data sets to provide useful results.

Fuzzy sets compress data by grouping objects that have similar attributes, are closely located in space or time, or have similar functions. This grouping process can include crisp and fuzzy objects, which are physical or virtual, with resulting fuzzy sets being dense or sparsely populated (Zadeh, 1998:24). Incorporating membership values maintains information about each object, while building a map of the information. As Kostek acknowledges, characterising each fuzzy set by its natural language label ensures the original data remains user-friendly in fuzzy set form, and meaningful in further calculations (Kostek, 2004:1112-1113).

In conclusion, these five principles of fuzzy logic theory provide an excellent platform to work with music in many domains, in particular the subjective experience of music as it occurs in real time listening. The value of fuzzy logic has already been recognised by researchers working in various applications of technology to music problems, and is starting to be recognised by European musicologists as a valid line of analytical enquiry.

⁸ This is particularly relevant to working with the contents of group structures in music, such as phrases. While phrases occur in many types of music, the actual phrase contents are unique to different pieces of music.

3.2 Existing Applications of Fuzzy Logic to Music Problems

This section provides an overview of existing applications of fuzzy logic specifically to solving problems in music. Working through this literature is a fuzzy mapping exercise of its own. There are no recognised textbooks or authorities in the field and there is no cumulative body of work in music applications of fuzzy logic where researchers build on and extend the work of other investigators. Only two research teams each continue to develop and extend their own application of fuzzy logic to music problems over time: a Swedish research team based at the Royal Institute of Technology, Stockholm (KTH)⁹, and another in Spain initially started by de Mantaras and now expanded by Arcos and others. In general, researchers work on an isolated one-off project, while occasionally others, perhaps with a postgraduate student or technical assistant, gradually extend their own projects in various ways. For instance, Cope working with artificial intelligence approaches to composing music, has incorporated Elsea's work on fuzzy logic into some of his own computer programs¹⁰. Other individuals incorporate fuzzy logic in one part of their work and then move on to developing other parts of the same project or entirely new projects, some of which have no relation to fuzzy logic¹¹.

As a consequence, there is no big picture of researchers taking up ideas of other researchers to build on their ideas, to extend, or deepen the original work. There is no comprehensive reference book that encapsulates the field of fuzzy logic and music. Rather there is an odd assortment of individual journal articles and conference papers scattered through disciplines of cognitive psychology or computer science or occasionally in publications directly focussed on specific applications of digital technology to music composition and performance. These are not mainstream musicology or music analysis journals. Most authors cite one or two other 'random' papers on fuzzy logic, with or without music, to situate their own

⁹ This team also works collaboratively with researchers from other parts of Europe.

¹⁰ This is referenced in Chapter 3 of *Computer Models of Creativity* (Cope, 2005) and published on his website (Cope, 2006). See p. 104 Elsea's fuzzy logic generative method has been used by Cope for more detail on this and other researcher's applications of Elsea's fuzzy logic composition module.

¹¹ For example, Whalley suggests that fuzzy logic might be useful for controlling modules in a composition engine for automating film scores (Whalley, 2002). However, his research has moved on to designing systems for real time improvisation that no longer explicitly mention fuzzy logic such as HIEMPA (Whalley, 2008) and GIMP (Whalley, 2010).

work. There are no respected authorities on the topic of fuzzy logic and music, although empirical researchers into music perception occasionally refer to Bresin and Friberg (the KTH team), while engineering researchers applying fuzzy logic in automated music production (robots) sometimes refer to Arcos and de Mantaras (the Spanish team). The review presented here acknowledges these overlapping strands of research as well as research that independently investigates quite similar ideas. One of the contributions of my thesis is to draw these independent research papers into an overview of the existing state of research using fuzzy logic to investigate various problems in music.

This literature review covers the period from 1992, the date of the first paper to apply fuzzy logic to music, to the December 2016 journal article by Kreković; Pošćić et al. The first published paper in 1992 concerns the problem of finding variations in pitch centres of melodic fragments in order to distinguish one fragment from another (Vidyamurthy and Chakrapani, 1992). Kreković, Pošćić et al. in 2016 describe their application of fuzzy logic to control a range of technical features that together contribute to the timbre of digitally synthesised sounds. There are many applications of fuzzy logic to addressing a variety of problems over the years.

Appendix G. Timeline of Music Research using Fuzzy Logic (see pp. 457-470) shows the year by year publications by subject area and research topic. Nearly all the work on fuzzy logic and music centres on automated methods for carrying out specific tasks, whether in composition, analysis or performance. Presumably, this arises from the background research questions that gave rise to fuzzy logic, namely the quest for computers to emulate human thinking and activities through artificial intelligence. However, several recent papers (Măniuş, 2010; Ciocan cited in Rădulescu, 2012; Heister, 2012a; 2012b) stand out as they are not directly concerned with machine automation issues. As will be discussed in more detail below, these precursors to my own research discuss the potential of fuzzy logic for understanding the logic of music, or to represent human thinking while listening to music, yet contain little practical application. These papers continue the tradition of being isolated examples of the application of fuzzy logic to an area of music study.

Throughout each domain of music analysis, performance and composition a number of researchers flag fuzzy logic as a useful concept. For example Chau (2014)

suggests that developing fuzzy logic applications could be useful in allowing computers more significance in music teaching and learning (Chau, 2014:237). However, they have yet to reveal how fuzzy logic might work in practice. Possibilities for future developments include machine-listening software for 'blind' identification of individual violinists through matching nuances at the phrase level of their playing of commonly performed solo violin music (Molina-Solana, Arcos et al., 2008; 2010). A concept design for an automated composition system that will generate music for film, based on archetypal emotional narratives, includes a black box fuzzy logic controller to impact on the performance aspect of the music (Whalley, 2002). The contours of the variables required to play out the emotional narrative need to be predetermined and fed into the black box fuzzy logic controller. This, however, remains operationally unspecified.

Returning to human activity, a critique of computer music demands that the experience of listening to that music generates a positive emotional response (Milicevic, 1998c; 1999a; 1999b; updated 2002). Milicevic's series of papers give a passing mention of fuzzy logic at a propositional level for understanding "...musical patterns and their anticipation and predictability by the human brain" (Milicevic, 2002:127). Fuzzy logic has also been suggested as conceptually suitable for analysis of contemporary art music because music as an artform is grounded in uncertainty and ambiguity (Măniuț, 2010:201). In somewhat more detail, Heister suggests that conventional score-based analysis could be enhanced by the use of fuzzy logic for detection of motivic repetition, variation and development within pieces of music and between pieces of music (Heister, 2012b:400). In a related article, Heister notes that elements for analysis could include chords and melodic motifs as fuzzy analytical groups, rather than as individual notes (Heister, 2012a:428). He provides a conceptual example based on a sequence of four pitches which he suggests represents a religious motif that can be recognised in a score¹². Heister suggests that fuzzy logic could show how this symbolism contributes to the hierarchical structure of the music from note to phrase to section (Heister, 2012a:435ff). However, there is no actual analysis of the music, nor any application of fuzzy logic

¹² Heister does not refer to the audibility of the motif or its extensions throughout the experience of the music as heard, but he does explicitly mention how the structure of the music and the score is based on the motif and its variations.

methods to the score, beyond noting some elements of the score that could be seen as having fuzzy similarity.

Other analysts have suggested building on the ability of fuzzy logic to provide flexible descriptors for complex musical events. Fuzzy sets have been proposed as useful way to classify changes in textures over time when analysing Xenakis' *Achorripsis* (Kosona and Hadjileontiadis, 2012). However, texture and time have already been included in Xenakis' own description of his semi-algorithmic compositional process of this music in *Formalised Music* (Xenakis, 1972). Unfortunately, the concept proposal does not state whether the analysis is score-based or perceptually-oriented using the sound of the music.

These concept papers contrast with the practical application of fuzzy logic to music problems. Actual applications of fuzzy logic can be broken into three broad categories: automated music composition, automated music performance, and automated analysis.

a. Composition

The first application of fuzzy logic to automating music composition was through a small add-on to Max/MSP (Elsea, 1995, updated in 2011). The patch produces variations in chord inversions to manage the amount of repetition to generate melodic phrases with correct harmony in the correct location. In this work, an unconventional use of membership values means that they become weights for each of the possible choices to be made by the composition engine which causes some chords to be chosen more frequently. There is a built-in analyser which determines how many common tones there are between adjacent chords. This also affects the decisions, as do the number of identical chords produced by the patch immediately before the chord is generated. This patch is grounded in tonal music, designed to produce triadic chords in a defined key. This patch/module has been officially incorporated into *Max5* ('74, 2013). Elsea's fuzzy logic object has been directly used in other composers' work, such as *Weathersongs: Days in Wales I* (Garrett, 2006). Part of the Elsea's fuzzy logic generative method has been used by Cope in the module 'Fuzzy Function' as part of an automated composition engine programmed in LISP, referenced in Chapter 3 of *Computer Models of Creativity* (Cope, 2005) and published on his website (Cope, 2006). This LISP module generates MIDI chord

sequences with good voice leading and sufficient variation but does not include the phrase generator.

Similarly, composer programmers have applied fuzzy logic to automated production of music in score form, which can then be performed by humans or MIDI machines. Fuzzy logic has been used in rules that generate note against note counterpoint from a given *cantus firmus* (Yilmaz and Telatar, 2009). Judged against the strict theoretical rules of species counterpoint, their compositional engine produced too many errors, requiring extensive further development. Tonal harmony must be relatively easy to replicate by machine, because their four part harmoniser seems to work much more effectively when judged by human analyst-listeners, but at this point only harmonises an eight-note bass line (Yilmaz and Telatar, 2010). Similarly, an automated ‘proof of concept’ composition engine used fuzzy logic to generate functional harmony for a scale progression, in lieu of a melodic line, to produce printed scores of several pages which incorporate the nuances of human performance through controlling amplitude and duration of individual notes (Raes, 2009; Raes, 2016). Other examples not humanly possible to perform, but performable by MIDI machines, are available on CD and on the internet (Raes, 2000; Raes, 2004; Raes, 2004). More realistically, fuzzy logic has been applied using tonal principles at multiple levels of phrase and bar structure to select chords to harmonise a real-world 40 bar Latin melody. Interestingly, their work also attempts to integrate aspects of human influence on the ‘atmosphere’ of the music through a feedback system where the chosen harmony affects the membership functions that in turn affect the chosen harmony. The system produced 80 per cent correct choices in comparison with its conventional human harmonic scheme (Tokumaru, Yamashita et al., 1998:353).

The *jMusic* program, a Java programming interface, enables composers either to program computers to make their own compositions through their own lines of code, or by using a variety of pre-defined modules to assist in their work. *jMusic* is based upon note/sound events being collected into monophonic phrases that can be built into a hierarchical structure to form sections of music. *jMusic* can read and write MIDI files, audio files and its own .jm files. While its primary goal is to support composition, it has also been effectively used for live performance, musical analysis and computer music education (Sorensen and Brown, 2000). One of the pre-defined

modules is called 'fuzzy logic'. This module provides a means for mapping ranges of crisp numbers in one domain (such as the MIDI loudness range 0-127) to the fuzzy 'dynamics' categories used by musicians (such as *pianissimo*, or *forte*). This means the composer can write their composition program with data in either format should they wish to change the dynamic levels of their music (Sorensen and Brown, 2004). Similarly, a fuzzy logic module in JavaScript has been developed for Max/MSP at IRCAM. *FuzzyLib* (Bonardi and Truck, 2007-2009) can be used to control any parameter of music, whether in audio or MIDI. However, *FuzzyLib* is somewhat more complex as it is capable of mapping one input parameter to multiple output parameters while providing the user with choice of five fuzzy inference engines. This is more complex than the fuzzy logic module developed by Garrett, and implemented in *Ableton Live*, to control the texture in a polyphonic MIDI composition (Garrett, n.d.).

Another fuzzy logic based engine for simultaneously controlling several attributes of sound synthesis in *Max/MSP* and *Pd* is designed for real-time composition using various pre-existing sound synthesis techniques, such as granular synthesis, spectral synthesis or physical modelling. The basic fuzzy logic engine has been described in some detail (Cadiz and Kendall, 2006) that show how this controller explicitly includes the time domain determined interactively by the audio output (Cadiz, 2006). This module is exclusively concerned with the dynamic alteration of a continuous stream of monophonic digitally synthesised sound. Cadiz has also constructed a fuzzy logic sound synthesis algorithm which maps four visual parameters into sound parameters such as loudness and frequency over a predetermined time scale plugged in by the composer (Cadiz, 2006a).

A variation on this theme is a real time composition engine using MIDI data to control robot performers. This contains a fuzzy logic module to decide texture by determining how many robots play at any one time, and how frequently and on what parts of the beat they play notes (Eigenfeldt, 2007a; 2007b). Recently the application of fuzzy logic has been extended to ensure there is sufficient motivic variation in the output of the composition engine (Eigenfeldt, 2011).

b. Performance

A significant aspect of music production is the actual performance of music. Fuzzy logic has been applied experimentally to successfully affect the output of several physical organ pipes to enable them to be more responsive to a player's expressive requirements during live performance (Kostek, 1999). Similarly, the output of digital drum machines has been altered to make performances seem more human, and less mechanical, by means of variations introduced using fuzzy logic (O'Sullivan and Boland, 2010). While this was successful in terms of audience perception, the humanised performance could not be implemented in real-time. Their method required the desired nuances in articulation and accent to be programmed into the computer for the whole piece of music.

Recognising that humans are capable of more nuanced activities than is permitted by nearly all computer programming, is also the concern of González, Cuadra, and Cádiz (2015). These researchers address the problem of setting the frequency equalisation (EQ) for individual pieces of music based on the actual attributes of each track, to improve on standard practice. Current practice relies on manually selecting an EQ from preselected choices based on genre, when listening to music on a digital playback system such as a smartphone. González, Cuadra, and Cádiz (2015) demonstrate that audio descriptors already well-developed for music information retrieval of different genres can be used in a fuzzy logic inference system to provide better EQ for songs that exhibit cross-genre characteristics.

By contrast, Marinos and Geiger (2014) explore the automated development of fuzzy logic rules through tracking a human conductor's predetermined movements during rehearsals. These rules then permit the human conductor to control a digital piano accompanying a human pianist during a live performance in real time. The human/machine interface then uses that fuzzy rule set during performance to convert the conductor's gestures into a MIDI data stream of three attributes (tempo and time signature, and volume). Marinos and Geiger's rationale for using fuzzy logic is that it allows the use of natural language to describe aspects of the gestures, the resulting outputs, and the rules. The value is that the system is then transparently comprehensible to non-technologists. Further, fuzzy logic assists in producing useful outcomes from complex interactive systems while

allowing/requiring the human operator the freedom to behave naturally. This contrasts with the interactive systems developed by Lindstrom, Camurri et al (2005) described below in connection with the KTH work on *Director Musices*.

Similarly, as noted above, limited to timbre, Kreković, Pošćić, and Petrinović describe a fuzzy logic controller using 57 rules as an interface for any digital synthesiser based on Virtual Studio Technology (VST) (Kreković, Pošćić et al., 2016:376). This interface produces the precise settings of inputs into digital sound synthesis after the desired timbral qualities of the sound are specified by human operators using one or more of seven predetermined natural language adjectives to describe the (yet to be) synthesised sound.

SaxEx is one of the first implementations of fuzzy logic, designed to affect the ‘expressiveness’ of playback of pre-recorded audio files of monophonic jazz melodies. The five attributes controlled by *SaxEx* are dynamics, rubato, vibrato, articulation and note attack. The system has been developed over a number of years by a group of Spanish researchers in Artificial intelligence led by Josep L Arcos and Ramon Lopez de Mantaras. The first publications outlining aspects of this system, primarily the use of case-based reasoning methodology, refers to qualitative descriptors but fuzzy logic is only flagged as a future development (Arcos, Canamero et al., 1998; Arcos and de Mantaras, 2001). The case memory contains audio examples of human performances, analysed into individual notes and their expressive qualities by means of Serra’s spectral modelling techniques (Serra, 1997), along with background musical knowledge, derived from a MIDI representation of the score. Each inexpressive input note, again derived from audio recordings, is tagged with information regarding its role in the musical phrase to which it belongs. This enables the retrieval of notes with similar roles (from the case-base of human performances). Several early papers by propose the application of fuzzy logic in future stages of development (Arcos, de Mantaras et al., 1998; Arcos and de Mantaras, 2001). Yet by 2000 these researchers had already introduced fuzzy logic as a means of aggregating data for each expressive parameter from retrieved cases of an individual note in a specific location within a phrase. These aggregations (similar to averaging) are then used as the control values for the expressive parameters to operate on the recordings to make them more expressive (Arcos and de Mantaras, 2000). This development was also detailed in later

publications (de Mantaras and Arcos, 2002; Arcos, 2012). The later papers outline how the next step uses fuzzy logic to aggregate the information from the best matches among the retrieved notes for the type of expression desired for the final output. The final step is to transform the input note so that its expressive properties (dynamics, rubato, vibrato, articulation, and attack) match the average values returned from the fuzzy aggregation of the most similar retrieved note (de Mantaras and Arcos, 2012:26). Alternatively, the user of the system can select the degree of similarity to the retrieved cases to be implemented by the system, in which case the fuzzy aggregator is bypassed (de Mantaras and Arcos, 2002:53).

A similar comparative system based on monophonic MIDI data has been developed by Arcos, Guaus et al. (Arcos, Guaus et al., 2013). The research concerns detecting errors in timing and loudness of each note in a single performance of classical guitar music¹³. This implementation takes the score as base standard for comparison and uses fuzzy logic to report these results in easily comprehensible visual form to assist individual students practice more effectively. The system is constrained to three fuzzy sets for each of three factors assessed for every note in the music (Arcos, Guaus et al., 2013).

In contrast, the team at the KTH-Royal Institute of Technology, Stockholm have been building on the initial work by Bresin et al (1995) to implement fuzzy logic in the analysis of audio and video streams for expression of three individual emotions. The KTH rules for the expressive playback of MIDI files had been developed by Friberg over a number of years, building on the work of Sundberg who developed expressive vocalisations for computer voices. *Director Musices* is the formal name of the KTH rule set initially developed without any application of fuzzy logic. The KTH rules were designed to take a MIDI score and change it to enable it to be played back by MIDI machine with emotional content. The KTH rules are based on three attributes in music that contribute to its emotional content: amplitude, articulation and tempo. In 1995 an Italian team altered the KTH rules to test the effects of fuzzy logic as a means of influencing the MIDI output (Bresin, De Poli et al., 1995). This application of fuzzy logic reduced the number of rules necessary from thirty to

¹³ Classical guitar music in contrast to rhythm guitar parts in popular music is generally not chord based, but a sequence of individual notes. The fuzzy logic system developed by Arcos, Guaus et al. (Arcos, Guaus et al., 2013) is not able to function with simultaneous notes in chords.

seven, while analyst-listeners could hear no difference in the end product. Friberg built on this work in his implementation of fuzzy logic rules to allow a dance to control three attributes of monophonic music in real time (Friberg, 2004). As described by Camurri, De Poli et al (2005), through a series of experiments that form the *MEGA Project (Multisensory Expressive Gesture Applications)*, *Director Musices* has also become a component of multi-media interactive performance systems. Fuzzy logic is applied in these digital environments to transform continuous movement and audio information into qualitative categories. As Lindstrom, Camurri et al, describe this means dancers can control the 'emotional' quality of digital music played by an automated DJ. Similarly, game players can control the music and the game play through their singing or movements through a pre-programmed module that uses fuzzy logic to extract emotion cues from the players' activities (Lindstrom, Camurri et al., 2005:71).

c. Analysis

The final application of fuzzy logic to music has been in the technical analysis of any single aspect of the multi-dimensional object we know as music. Fuzzy logic has been used as an analytical tool to classify the harmonic content of arpeggiated chords in MIDI format, where the scoring makes it difficult to determine which notes belong to a chord. Cope says that fuzzy logic analysis is effective at this type of operation, but does not provide any details of his analytical software (Cope, 2005:73-75).

Fuzzy logic has also been used to analyse melodic fragments for their tonal centres. The melodic fragments taken from audio recordings are analysed for their frequency spectrum over time. Fuzzy logic is used to determine the average frequency (Hz) of each melodic fragment so that variations and similarities between fragments can be evaluated for possible inclusion during an algorithmic composition process (Vidyamurthy and Chakrapani, 1992). Similarly, Quinn (1997), has used elements of fuzzy logic in machine listening to identify the similarity between the contours of 11 note monophonic melodies which have the same rhythmic pattern. Quinn, similarly to Vidyamurthy and Chakrapani (1992) uses averaging to determine a single number against which new melodic contours are compared Quinn (1997:256). Real world sounds and music samples to a maximum of thirty seconds in length are

analysed for technical similarity to enable correct classification of the sounds with respect to humanly perceptible differences in harmonic spectra (Eigenfeldt and Pasquier, 2010). Fuzzy logic is used to calculate the similarity between the samples according to summary statistics of the harmonic spectra at several time points for each sample. The purpose of this analysis is rapid recall of appropriate samples for use in real time improvisatory performances.

Other applications of fuzzy logic to music analysis are experiments for music retrieval systems designed to locate specific music in large databases, similar to searching for a book via a library catalogue and having the book brought to you. Monti and Sandler (2002) applied fuzzy logic to determine whether a peak in the frequency spectrum of an audio file does or does not represent a note as opposed to noise. Those peaks that are accepted as notes are classified into MIDI pitches by probabilistic tools, not fuzzy logic. These motifs are then used to search a database in order to retrieve scores that contain this motif. The overall purpose is to enable part of an audio file to be used as the search term for finding the score for that music. A similar application uses fuzzy logic to analyse MIDI note data for extraction of rhythms and groups of rhythms that can be matched against rhythmic motifs stored in the database (Weyde and Dalinghaus, 2003; Weyde, 2004). The final application of fuzzy logic to music retrieval is concerned with identifying thirty-second fragments of music in audio format into one of four genres on the basis of differences in harmonic spectra for each genre (Park, 2009). Fuzzy logic is applied to enable fuzzy sets, rather than a single value of the statistical mean and variation, to represent the harmonic spectra of the prototypical samples against which the fragments of music are tested for appropriate classification¹⁴.

Music matching systems are not strictly music retrieval systems as they are designed to match meta-data about the music, similar to using a library catalogue to match similarities in the content of single books within a library, rather than locating and retrieving the books. Gracenote maintains the potential to use fuzzy

¹⁴ The genres are country and western music, hip-hop, jazz and classical music. The authors remark that the classification system seems to work well, except in distinguishing between country music and classical music. What does this say about the similarities of those genres?

logic in its music identification service¹⁵. Gracenote is used by multi-national recording companies, such as Sony Corporation, to identify possible piracy of music and video. Gracenote music identification services are also used by Windows Media Player and other digital applications, as well as iTunes, to provide rich media content for users. The reference database compiled and accessed by Gracenote contains data on commercially released recordings provided by the music industry, along with additional information provided by listeners. The identification method is a stepwise process that starts with metadata such as song name and performer. Initially, results are validated by matching track length between user and reference recordings. Audio content is only analysed in cases of uncertainty about the results returned by metadata (Roberts, Hyman et al., 2003). The audio content is analysed by means of 'fingerprints' that document the frequency spectrum over a short sample of the music (Roberts, Hyman et al., 2008). Recently, Gracenote has included references to 'fuzziness' in its patent applications without specifying what they mean. Verification of matches by track length is 'fuzzy', while the fingerprinting process now includes multiple fingerprints from one recording that are fuzzily joined together to make a longer fingerprint record (Roberts, Hyman et al., 2013).

In a different type of analytical problem, fuzzy logic has been applied to two different tests relying on subjective evaluation by a group of audio engineers regarding the quality of the audio output from software used to emulate acoustic qualities of various architectural spaces, such as a church or a small lounge room (Kostek, 1999:165-183). The evaluation is based on each of five predetermined attributes, such as introduced distortion, and clarity of sound. In the first test, Kostek simply applied fuzzy logic principles to categorisation by asking each subject to rate each software for each attribute on a predetermined five-point scale in natural language, after listening to two 15" excerpts of music modified by each software. The cumulative results, reached by simple addition of all test subjects who rated this attribute as 'excellent' for particular software, was presented in visual form that shows the relative excellence of each piece of software in producing each attribute (Kostek, 1999:166). Thus if the engineer wanted to reproduce the

¹⁵ Gracenote matches metadata, such as genre, album name, recording label, song name and performer (Roberts, Hyman et al., 2013) from the user's personal music library with metadata in a large reference database supplied by the music industry and consumers, including *iTunes*, only using audio data to validate the results or eliminate errors, possibly using fuzzy logic in the matching algorithms.

booming echoes of a cathedral she might, based on these test results, choose to use software #2 to give the best result.

The application of fuzzy logic was extended in the second test, designed to provide an overall evaluation of each software's performance. Here Kostek first fuzzified the qualitative responses regarding an attribute on each five-point linguistic scale. She then used the logical inference mechanisms of fuzzy logic to calculate the combined experts' relative evaluation of the overall performance of each specific software. However, she next used her own formula to determine the contribution of each attribute to the overall evaluation (Kostek, 1999:176). In both tests the choices available to the evaluators were predetermined at each step by the researcher, so that Kostek only applied fuzzy logic to fuzzify their qualitative information into numerical data. This allowed her to use her own fuzzy logic operators to provide finely detailed information about the relative importance of the whole group's overall evaluation of each attribute for each piece of software. Kostek's practical demonstration of her application of fuzzy logic principles affirms the approach I developed for *Fuzzy IDEAS*.

In conclusion, this review of previous research shows that some researchers in musicology are aware of the promise of fuzzy logic, while composers and computer scientists are already engaging with fuzzy logic to work with individual technical aspects of music production primarily in automated performance, analysis and composition systems.

The new method outlined in this thesis is designed to engage equally with all the materials of music while focussing on listening as a sense-making experience. Using fuzzy logic allows the examination of a broad range of Western music through two lenses simultaneously: first, the detailed elemental perspective - the multi-dimensional construction of individual sound events in each piece of music; second, the time domain perspective - how all these elements, and their variations, change and combine over time. The new analytical method will focus on listener perception and reception as the primary source of information about the music.

3.3 Listener-Oriented Music Analysis

Existing research into music problems using fuzzy logic is generally concerned with analysis of selected technical aspects of music to solve problems in identification of individual pieces of music, or in automating human music performance practices. However, as Morrison argues, the potential value of music analysis lies “...in the need to discriminate in music (as in all the arts) between different works, styles and manifestations, even of each individual composer...” (Morrison, 1985:ii). Chapter 1, Section 1.3 (see pp. 47-58 above) explored why avant-garde music can be challenging to understand. My research question is concerned with using fuzzy logic to connect analysis that includes any technical aspects of the music with how this specific music makes sense to a listener. The analytical method to be presented in this thesis is a concrete realisation of recent proposals that fuzzy logic could be useful for interpreting particular types of art music (Măniuț, 2010; Ciocan cited in Rădulescu, 2012; Heister, 2012a; 2012b)¹⁶. Sense-making and aesthetic judgement are different but related aspects of valuing specific pieces of music. Although, as Darlhaus suggests, it may not be possible to reconcile analysis and aesthetic judgment (Darlhaus, 1983:vii), I am arguing that using fuzzy logic enables us to bridge the gap between subjective response and technical observations.

Importantly, the new analytical method presented here, moves beyond concept to become a practical system, which includes all possible responses to all sounds and structures in the music. Despite the common opinion, elegantly articulated by Lambert, that music as an art form is as naturally emotional as painting is naturally representational (Lambert, 1985:110)¹⁷, my new method is a broad open-ended approach to making sense of music on the basis of any idea, not only emotional

¹⁶ Rădulescu cites Dinu Ciocan, Romanian composer and musicologist, as using fuzzy logic in his 2005 semiotic theory, but a comprehensive search in January 2016 shows that this work is not available in English translation.

¹⁷ Interestingly, Lambert argues that not all music is capable of expressing all emotions. He asserts that classical music has little sense of horror or the macabre, not because composers despised horror, but because they were technically unable to achieve it with the harmonic conventions and formal structures of the period (Lambert, 1985:62). He goes on to argue that it was the harmonic innovations of the impressionist composers prior to WW1 which fully allowed music to express these darker emotions (Lambert, 1985:63).

response¹⁸. This is particularly important in relation to avant-garde music because some music is not written with emotional responses as the primary idea, so focussing on emotional response is too narrow. None of the current applications of fuzzy logic to problems in music address analytical listening for ideas. The new method presented in this thesis is completely unique in this respect. The new method is listener-oriented, with potential to be developed into ‘smart’ music analysis for the 21st century.

Flagging the new method as potentially ‘smart’ seems appropriate for several reasons. My thesis is concerned with schema and rationale for how such a ‘smart’ system can be conceptualised, as a necessary part of developing an automated system in the future. The new analytical method presented in this thesis is grounded in the intersection between artificial intelligence approaches to problem solving and mainstream approaches to making sense of music. The new analytical method retains intricacies of human perception by embedding the principles of fuzzy logic as the basis for classification of the perceived information, while using fuzzy logic enables meaningful visual analysis of the listening observations. The use of ‘smart’ as a descriptor for 21st century technology grounded in fuzzy logic is applicable, even though the new analytical method is not yet entirely automated. The new analytical method is designed as a systematic and integrated method that reflects human decision-making processes to establish the platform for future development of an automated ‘smart’ system of listener-oriented music analysis.

Summation

There are *prima facie* arguments supporting the application of fuzzy logic to describing music, as fuzzy logic seems particularly suited to the characteristics of music as an art form. Additional support for the application of fuzzy logic to music theory and compositional practice comes from diverse quarters. Together they build a compelling argument for exploring this as a fruitful line of research. The requirements set out by Babbitt (Babbitt, 1965) that any music theory be logical,

¹⁸ If nothing else, *Fuzzy IDEAS* may assist with “...reflections on premises and criteria of musical judgment” (Darlhaus, 1983:vii) which can help to define the problem inherent in making sense of a particular piece of music.

coherent, useful and intelligible are met by my application of fuzzy logic principles. Fuzzy logic is already being used to construct intelligent systems that can respond efficiently to variable contexts and input streams. As described in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see pp. 453-462) these systems are being developed across theoretical, physical, and digital information domains. Zadeh argues that fuzzy logic is an essential tool for the design of intelligent information systems because these systems reflect the world in which we live: imprecise, uncertain and full of partial truths (Zadeh, 1998:25). As mentioned previously, in recent years several European musicologists (Măniuț, 2010; Ciocan cited in Rădulescu, 2012; Heister, 2012a; 2012b) have noted the potential utility of fuzzy logic for music analysis because of the uncertainty of continuation of specific materials, such as melodic lines, and the use of variation as two hallmarks of music.

Fuzzy logic principles are specifically designed to incorporate ambiguity and uncertainty, which are significant features of music as it is aurally experienced, unfolding through time. Using fuzzy logic methods, it becomes possible to trace the detailed trajectory of individual music attributes and features and their interactions. This is important as it is the individual elements and their combination over time that are significant in the music's ability to achieve its goals. Fuzzy logic can be a useful way to approach these problems as it takes the actual state of affairs at any moment, with all its uncertainty, as its primary building blocks to create the form as an overall cumulative trajectory of the combinations of these building blocks. Fuzzy logic is a useful way of describing completely the elements and their interactions that contribute to the listening outcomes of music. In summary, fuzzy logic methods are pertinent to the problem of making sense of avant-garde music.

The most striking thing about fuzzy logic is its ability to contain, and work logically with, 'vague' concepts, hence its immediate applicability to musical discourse which is filled with terms that can rarely be precisely defined in numerical terms. The application of fuzzy logic principles allows the development of a terminology that incorporates dimensions of sound to ensure it is directly applicable across all genres of Western avant-garde music, including acoustic music and computer music. As Arcos, Guaus et al (2013) have recently demonstrated, fuzzy logic classifications can be articulated in visual form rather than mathematical symbols. The new analytical

method builds on this illustration to provide a transparent and meaningful, generalised tool to make sense of avant-garde music.

The literature review shows that investigations into fuzzy logic and music are scattered among journals in computer science and engineering, but rarely in music¹⁹. The review shows that no existing research involves the practical application of fuzzy logic to make sense of music from a listener's perspective. However, some recent developments do foreshadow my original research and contribution to knowledge made in this thesis. For instance, Măniuț, Heister and Ciocan, have each individually considered the conceptual relevance of the principles of fuzzy logic while Cope, Kostek, and Arcos have each applied fuzzy logic to analyse single aspects of music. None of these researchers have applied fuzzy logic in the wholistic approach I have explained and used in this thesis.

My new analytical method will be explained in detail in the next two chapters. The purpose of these chapters is to explicitly state as many assumptions as possible, along with providing a clear methodology so that the process can be replicated by other researchers. Chapter 4 details the method for documenting each individual experience of listening, while Chapter 5 details the practical implementation of fuzzy logic in the new analytical method.

¹⁹ To underline the sporadic nature of this research Appendix G. Timeline of Music Research using Fuzzy Logic (see pp. 459-469) shows the timeline of research questions and applications of fuzzy logic to music problems.

Chapter 4. *Fuzzy IDEAS*: Listener-Oriented Music Analysis

This chapter and the next set out the working methods of *Fuzzy IDEAS* as dialectical listener-oriented music analysis. *Fuzzy IDEAS* is designed to systematically analyse music for ideas by discovering how the perceived musical surface, and the observed formal structure of the music, contributes to the analyst's understanding of those ideas. In some respects, *Fuzzy IDEAS* resembles conventional music analysis.

However, *Fuzzy IDEAS* is designed to be generalised across styles and inclusive of all possible attributes of music while explicitly incorporating the human aspect of listening to music: the need to make sense of the experience. Auto-ethnography is an established research method that involves writing, rigorously and systematically, about personal experience.

This chapter discusses the need for an explicit auto-ethnographic approach to listening and analysis, as listening to any type of music is an aural encounter with sound in real time that can only be experienced individually and subjectively. Therefore the experience of music is necessarily an auto-ethnographic process because, as stated by Biles, "...listeners build a mental model of the piece which evolves over the course of the music" (Biles, 2007:4). Similar to Joseph Kerman, every composition is considered as much as possible without preconception "...to hear what it unequivocally offers as expressive logic" (Kerman, 1975:25). The method is specifically designed to be abductive, allowing possible interpretations of how the music makes sense to arise from the information in the qualitative listening observations as it is collected and analysed. The complete method to make sense of avant-garde music is a nine-stage process built on fuzzy logic principles.

Setting out the method step by step means the method can be replicated by other researchers. The new analytical method, *Fuzzy IDEAS*, draws on practices from auto-ethnography; machine-listening analysis; the case study principles of musicology; and the repeatable scientific methods of experimental psychology. Each stage incrementally refines the listening experience into something assessable across different pieces of music. Eventually, this information could be used to make comparisons between different pieces of music. However, the primary purpose of

Fuzzy IDEAS is to make sense of an individual piece of avant-garde music, and the primary purpose of this thesis is to explain the new strategy.

Fuzzy IDEAS explores listening to music as a necessarily auto-ethnographic practice because music, as an aural experience in real time, can only be experienced individually and subjectively. A listener has the potential to become an auto-ethnographic researcher into that music. The entire method of *Fuzzy IDEAS* is grounded on the principle that a listener can give useful insights into the music if they use auto-ethnographic methods, in particular the inclusion of their listener/researcher responses, as well as naming those properties of that music that this listener observed. Secondly, the analyst is required to document their process of fuzzifying the qualitative listening observations, and their process for making sense of the music based on evidence from the visual representations.

For easy reference, the stages of *Fuzzy IDEAS* are summarised below in Table 4.1. The Stages of *Fuzzy IDEAS*. However, this chapter is concerned with the first part of the method: documenting the process of listening to the music, and making sense of music immediately after listening to the music. This chapter has an emphasis on explicitly capturing the subjective idiosyncratic personal responses to the sound of the music as it unfolds, and thereby enabling real time to be incorporated into the analysis. The final part of this chapter, Chapter 4, provides the systematic work flow used to document the technical features and cognitive attributes and initial abductive hypotheses about a possible story/idea that makes sense of the music.

The next chapter, Chapter 5, particularly Section 5.1 Converting Qualitative Listening Observations into 'Fuzzified' Data (see pp. 158-164), sets out the details of how an analyst can use my fuzzy logic paradigm to organise and code the listener's qualitative observations into a hierarchy of fuzzified data: attributes and their constituent feature sets. These levels of fuzzified data are then mapped onto timelines to produce detailed visual representations of the listener's experience. These visual representations are then analysed to discover the significant attributes and features of this experience of this music. This investigation uses tools similar to those used to analyse digital audio streams, such as frequency distributions, Transition Pairs, and envelopes of complexity. This analysis is designed to provide evidence for the final abductive interpretation of the music. The final stage of *Fuzzy*

IDEAS (see Chapter 5, pp. 193-195 below) is where the analyst considers how to make sense of the music by using these analytical results in conjunction with the listener's initial thoughts about the title, along with any attempts by the listener to make sense of the sound of the music while listening. However, this thesis is not concerned to prove that any of the ideas that make sense of the music are correct, nor that they are heard by many listeners. Rather the purpose is to demonstrate that fuzzy logic provides tools for a systematic method that can handle the variety of organisation and the range of materials used in composing avant-garde music.

Table 4.1. The Stages of *Fuzzy IDEAS*

Stage of Method	Brief Description	Rationale
1. Documenting Pre-Listening Pre-Conceptions	Before listening to the music, the listener documents any expectations of what they are about to hear based on their personal attitude towards, or experience of, this style of music; prior knowledge of the composer, or circumstances surrounding the composition or presentation of the music; including any expectations arising from contemplating the implications of the title of the piece of music.	The purpose of this stage is to identify what the listener brings to this particular experience, and the initial abductive possibility for how the sound of this music is going to make sense.
2. Collecting the Qualitative Listening Observations	While listening to the music in real time, the listener uses writing tools to document the time point at which each qualitative listening observation is made along with their qualitative observations about technical aspects of the sound of the music, as well as any thoughts, impressions, or memories that come to conscious awareness.	This set of time points and qualitative listening observations is an initial record of the perceptual and cognitive responses of the listener as they listen to the music in real time.

3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience	The listener's documentation concludes with an account of the immediate impact of the complete piece of music for that listener.	The abductive possibility on how the sound of the music does make sense.
4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations	This stage considers any problems reported by the listener while collecting their qualitative listening observations. This stage also lists the details of those qualitative listening observations which contain cognitive attributes along with the time points of their occurrence. All documented time points are quantised downwards to the nearest five seconds.	This stage identifies those things which have impacted on the nature of the qualitative listening observations, as well as documenting the most subjective aspects of listening: the listener's thoughts and self-aware responses as the music unfolds.
5. Converting the Qualitative Listening Observations into Fuzzified Data	The purpose of this stage is to use fuzzy logic principles to classify the qualitative listening observations into my hierarchy of 'fuzzified' data by means of my coding taxonomy. The resulting hierarchy of 'fuzzified' data describes each qualitative listening observation at two different levels of detail: attributes and fuzzy feature sets. This stage also contains details of specific problems, if any, encountered in the conversion process for this specific music.	The coding taxonomy provides a consistent and systematic way of organising and categorising the qualitative listening observations into fuzzy logic entities.

6. Constructing Visual Representations of the Fuzzified Data	The visual representations are constructed from the fuzzified data for each sound event at attribute and feature set level, using my specialised mapping procedure. The time interval selected for transferring the fuzzified data into the visual representations is based on the smallest time interval between quantised time-points.	The purpose of this stage is to report the fuzzified data in a visual format which directly represents various aspects of this personal experience of the music.
7. Analysing the Frequency of Fuzzy Entities in the Visual Representations	This stage summarises the information conveyed by the visual representations to draw out those attributes and features highlighted in this single experience of the music.	These significant occurrences imply that these specific qualities have been emphasised by the composer. Relative frequency of attributes and feature sets also indicates the amount of variation between individual sound events.
8. Analysing the Time Structure of the Visual Representations	This second part of the analysis of the fuzzified data explicitly focusses on visual analysis of the time-patterning of attributes, features, and Silence events.	Visual analysis is achieved by constructing a series of simplified time series charts from the earlier visual representations. Each of these analytical charts focusses on a single aspect of the time series representations of the fuzzified data.

9. An Abductive Interpretation: The Idea that Makes Sense of this Experience	The structured analyses of the visual representations are synthesised and incorporated to link observed technical features of the music with the idea that makes sense of this experience. These abductive conclusions follow through on earlier hypotheses formulated immediately before listening presented in Stage 1, and immediately after listening presented in Stage 3, as well as the implications of the analyses presented in Stages 7 and 8.	This Stage draws out the overall key idea suggested by this experience of the music, and what this experience suggests about the compositional design.

4.1 Mediating Effects on the Sound of the Music

If music is not performed, it does not exist. Because of this necessity the performer is an agent who can and does mediate the expression of ideas, but not the idea on which the music is based. There is a distinction between what performers contribute to the music as it is heard, and aspects of the music that can only be controlled by the composer, such as structure, harmony, tonality and melodic progressions. The actual foundation upon which the music rests is its composition. This is recognised in Western art music, where the composer is always mentioned in connection with their music¹.

The confusion between compositional input and performance efforts reflects a problem in acknowledging a fundamental property of music as an artform: its aurality, and the consequent problems of making sense of a transient, intangible experience. Rather than explicitly acknowledge these inherent properties of music, researchers confuse the locus of expression.

¹ Only in popular music does the performer get the credit, thereby implying they are the most significant influence on the music. It is a distinct possibility that popular music is, in a sense, composed by individual performers as they arrange and rearrange things to suit their personal styles. Perhaps this is only an exaggerated version of nuances in performance of art music. Rather, I suggest the tradition of acknowledging the performers as instigators of meaning in popular music is due to this music relying much more on an oral/aural tradition, in which scores are only secondary.

“Expression” in the *Oxford Companion to Music* (Scholes, 1970:337-339) demonstrates the traditional stance on this topic. Although titled “expression” the section is clearly concerned only with performance as the entry starts unequivocally with “Expression in performance...” without additional remarks on “expression in composition”. The rationale is supplied by Percy Scholes’ definition of expression “...that part of the music which the performer must supply out of his [sic] own musical sense and emotion”, because the composer is not able to notate these events into the score (Scholes, 1970:337) while “...much modern music and old music re-edited is ‘overmarked’ giving the performer little latitude for expressing the music as he feels it” (Scholes, 1970:337). Clearly Scholes believes that the composer’s only role is to guide the performer, as do Joyce and Michael Kennedy who confine the composer’s role in expression to “...indicate speed and the kind of mood to be expressed by means of conventional music terms written on the score” (Kennedy and Kennedy, 2007:224). However, Kennedy and Kennedy are not alone. Luis Ariza also claims it is the musician’s interpretation that makes all the difference. The performer effects expression through the amount of vibrato, pitch bend, and tone (timbral quality). The composer is limited to indicating the sequence and some details of each note such as its pitch, suggesting timing, and loudness (Ariza, 1998).

Composers document their ideas to be projected through music in a variety of ways, whether in scores, graphic notation or computer programs. This documentation is technical, being a means for communicating intended aural experiences to be produced by performers. However, as discussed in Chapter 2 (see pp. 71-75 above) the actual performance of the music will contain small or large alterations to details of the music, simply because human performers add small variations to the timing of events, never playing the score as precisely notated, nor as mechanically as a metronome (Barth, 1992:160). Perhaps as psychologists, Sloboda and Juslin, suggest “Music creates an environment where the detected emotion can be fluidly ascribed to composer, performer, the listener (myself), or to God. There is no real life situation which can be created to challenge this ascription to the source of the emotion” (Sloboda and Juslin, 2001:87). However, “It is certainly a mistake to assume that the expressive powers of music, however great or limited they might be, lie primarily in the ... execution as distinct from the composition as notated” (Randel, 1978:162). Although performance is thought to make a difference to

expression of ideas in art music, Juslin and Laukka argue that perhaps, the differences are similar to the way the same words can be said with different inflections. Different delivery does not alter the literal meaning, but can affect the way in which the content is perceived and received (Juslin and Laukka, 2003:774-775). For instance, Philip Glass, contemporary art music composer, speaks about his music: “I find that when other people play my music...they play it in this robotic fashion, but I am aware of the dialogue and personality of the piece. My gift is to express it in a personal way” (cited in Hallett, 2011). This echoes Beethoven’s insistence that performance of his music requires small scale tempo modifications, detailed amplitude changes, and specific articulation to make the music expressive (Barth, 1992:158). However, as Boulez asserts “The code of a great work is itself sufficiently flexible to sustain an irrational, emotional and affective interpretation that may transform it and make something interesting of it” (Boulez in Deliege, 1976:65). Music is not what the composer wrote on the page, whether in traditional notation or in computer code. The composer’s ideas are mediated by the technology of sound production whether this comes in the form of human performers, or electrical equipment.

Another factor that affects individual reception of live acoustic music is the location of the presentation. Some rooms enhance some frequencies more than others, while the sounds are not always equally audible throughout a particular venue. Sound designers, such as Harada (2001), report that even in prestigious opera houses, microphones are sometimes installed on stage, not to amplify the singers but to ensure even sound reproduction throughout the auditorium, so that all audience members experience the same quality of sound. However, these intermediate technologies (microphones and other digital interfaces) may amplify certain frequencies and attenuate others.

Further, although the individual perception and reception of music in real time, is usually seen as an unmediated experience, there is a range of physical factors which can impact on the experience of listening whether to recordings or to live performances. For instance, an individual’s ears have different physical capacities across the audio frequency spectrum (such as being able to hear extremely high frequencies), or in their ability to distinguish important sounds from background noise (such as hearing a dinner companion in a noisy restaurant). The experience of

music is not only mediated by the variations in human hearing and sound reproduction technologies, but also the attention potential of the listener, as well as their individual capacity for self-awareness and insight, and capacity to articulate their impressions.

4.2 Abductive Method for Emergent Ideas

Fuzzy IDEAS is a more inclusive method of music analysis. The method is designed to work across all styles of Western avant-garde music, including instrumental/acoustic music, as well as computer/tape/electronic music and *musique concrète*. Further, the method uses the whole of the music, not only one part of it, whether this part is taken from the texture, such as the melodic line; or a small section of the entire piece of music, such as phrases, sections or single movements. *Fuzzy IDEAS* includes the potential to consider any attributes that influence the construction of music including all possible nuances of individual sound events, all sound types and noise. *Fuzzy IDEAS* is constructed on the premise that all elements of the music are equally important in compositional decision-making and potentially in listening. Similarly, *Fuzzy IDEAS* is designed to include all possible ideas as potentially communicated by the music, not only emotions.

Composers somehow take different facets of time into account during the compositional process. As Whalley points out, modelling the “dialectic between structure and event in a temporal framework gives a composer one indication of the way a work may be received” (Whalley, 2000b:149). Human composers are able to ‘recall’ previous events whether through complete reproduction, or by replication of, or allusion to, significant elements which point back to the original events, while also creating the conditions to make sense of events which are still to take place. This is the act and craft of composition. The human composer takes all these different perspectives into account when designing the work as a whole. “Composers must know how to spin their works out slowly and creatively over larger spans of musical time” (Cope, 2005:222). For instance, Cope points out that “Works *end* not just *stop* [his emphasis] (Cope, 2005:241). In relation to tonal music, he goes on to say that “Composers take into account the cadential goals, and

where they are in the piece, even if they are composing linearly from start to finish. There are “ongoing negotiations” between the moment and the goal.”

The goal of my new method, actuated in this thesis as *Fuzzy IDEAS*, is to make sense of avant-garde music. As outlined in Table 4.1. The Stages of *Fuzzy IDEAS* (see p. 119 above), plausible ideas that make sense of the music emerge from the listening experience through several stages. Firstly, informed by the possibilities suggested by the title, the aural experience itself will spontaneously provide ideas during and immediately following listening to the music. Secondly, analysis of the qualitative listening observations through later stages of the method confirm those initial ideas or suggest alternatives. These ideas are not pre-determined before listening and then confirmed by the evidence, but rather emerge from the observations of the sounds as they unfold over time.

My aim is to explore the intersection of the supposed subjectivity of listening and the supposed objectivity of analysis by using abductive reasoning. As Douven explains, abductive reasoning means no prejudging of what analysis might reveal, but simply listening, recording, and observing the cumulative outcomes of an investigation as it unfolds to form developing hypotheses which best fit the available information as it comes to light (Douven, 2011). The goal of the new method is to focus on the information available in a single listening experience to both rationally and intuitively make sense of the music².

In comparison, as Cope explains, inductive reasoning draws hypothetical conclusions simply on the basis of comparing observed characteristics, whereas deduction involves developing a theoretical construct, then finding evidence to fit or disprove those hypotheses (Cope, 2005:288). The language of ‘inductive reasoning’ is often used by researchers in music and multi-media systems³. Inductive reasoning is the basis of scientific empirical experiments for which evidence is gathered using specifically designed methods to test specific hypotheses. The scientific method not only documents the techniques so the experiments can be reproduced, but is

² As Langer explains “Science may have blinded us to sensuous knowledge as possibilities gave way to probabilities: in searching for the ‘right’ answer, the potential alternatives and our intuition are both dismissed or held constant” (Langer, 2005:183).

³ For example “Analogy provides interesting opportunities for creative thinking through inductive association” (Cope, 2005:218).

carefully designed to provide sufficient evidence to support generalisable conclusions. These conclusions can be used to develop theoretical assertions or hypotheses to explain what has been discovered and to predict future behaviour based on these theoretical linkages. However, inductive reasoning cannot be used to prove that hypothesis is definitively correct. Facts gathered during scientific experiments have value because they increase the amount of human knowledge, but they still cannot be a complete explanation of the phenomenon being studied. It is never possible to be completely certain that these hypotheses or theories are true, as the possibility always remains that eventually evidence will be uncovered which will invalidate the theory ('Deductive, Inductive and Abductive Reasoning' Center for Academic Success, 2008).

Fuzzy IDEAS does not aim to establish that this is the one and only correct interpretation of the composer's communicative intention based on predetermined variables. Instead, the method remains constant, but the variables and their interactions are altered depending on the listener and the music. This is especially necessary in the present day when there are so many different compositional methods, based on different rule systems, although working with the same basic palette of possible sonic attributes, but producing so many different types of avant-garde music. Consequently, 'abductive reasoning' is a more accurate description of the sense-making process as an emergent property of the listening experience⁴.

The primary difference between abductive and inductive reasoning is that inductive reasoning requires sufficient evidence to draw valid conclusions for making general theories. By comparison, abductive reasoning can be creative and intuitive, moving from the observation of some events to join a variety of things together in innovative ways to provide the simplest explanation of a particular combination of observed events (Douven, 2011). Abductive reasoning makes the best possible explanation of a set of incomplete observations. It makes the best guess based on the information at hand. Abductive reasoning is more suitable for making sense of an experience in which, despite the listener being presented with all the music, the listener can only be consciously aware of some aspects because of limits on human perceptual and cognitive processing.

⁴ Even if it does only take a listener two seconds to decide that they are listening to meaningless noise.

4.3 Material Requirements

This section outlines the method for collecting information about a single listening experience in relation to my specific research question of explicitly including real time sound of the music in analysis. Collecting information from listening in a concert-like situation influences many aspects of the design. The music is listened to from beginning to end in one sitting only, although the music is presented through a stereo sound reproduction system, while using writing tools⁵ to make free-form qualitative listening observations about the music as it unfolds. Each of the qualitative listening observations may contain three elements:

- A qualitative linguistic description of what is happening in the music that has become the focus of the listener's attention at that time.
- The listener's state while listening and any particular thoughts about the music occurring at those times.
- Time points that are not predetermined, but simply record the elapsed time at which each of the qualitative listening observations were made.

This method allows collection of cognitive responses as well as some details about the sound of the music as it unfolds. As Emery Schubert, an Australian researcher into the psycho-acoustic relationship between music and emotion, observes, empirical research that uses continuous response methods to record emotional responses to music need further analysis of the music to determine in detail what was happening at those times in the music when the participant responded (Schubert, 2010:229). Collection of all these details allows us to dig into this personal experience of the music to find out what features stand out to that listener and the impact of these features and compositional design on how the music makes sense. Collecting all this information allows the analyst to explore the impact of compositional design on the perception of specific ideas.

The actual qualitative listening observations must include elapsed time. As noted by Schubert "An undeniable, fundamental property of music is that it requires time to

⁵ I recommend handwriting as the most flexible way to capture the potentially vast variety of descriptions and time points.

exist. Any definition of music must include this property, even if by implication. For example, the well-worn definition of music being ‘organised sound’ does not explicitly mention time dependence, but sound requires projection through space and time as an absolute minimum” (Schubert, 2010:223). However, the implicit assumption of time is not sufficient when it comes to empirical research into music, as time itself is such a fundamental property of music. Although this lack of depth may have originated before sufficient computing power existed to handle the computational loads, this is no longer relevant as computers are able to handle the large data sets produced by time series. Personal experience of time also impacts on how the listener makes sense of that music. Listening and making sense of music is a dynamic process. As Al Biles notes “...listeners build mental model of the piece which evolves over the course of the music [over time] (Biles, 2007:4).” Clock time will only be recorded when something in the music has caught my attention. As noted on p. 134 below, using recordings as the performance medium provides the means to record event times quite accurately.

The aural experience of the music can potentially be framed by information from many sources such as program notes, from general knowledge of music and social history, or specific detailed research from musicologists, as well as the formal title (given by the composer) and informal title (given by publishers or initial audiences of this music). These may all give some insight into the ideas the composer may be expressing through this music, yet there is no guarantee that these texts accurately capture or describe the ideas behind the music. It is the music itself in which the ideas are embedded. It is the aural experience of the music itself with which the listener is concerned. *Fuzzy IDEAS* is designed to use the aural experience of listening to address these types of questions: What does the music suggest about the composer’s reasons for writing this piece in this way? What technical features causes this perception of the composer’s ideas in this music?

Fuzzy IDEAS is based on low-scale technology to make it human oriented, and explicitly incorporates the subjectivity of the listening experience by a human brain between two ears, which has its own thoughts and ideas. The high level of abstraction in a music score, and the way analysts talk about music, both limited to pitch, harmony, and rhythm, are challenged by the methodology of *Fuzzy IDEAS*.

The new method needs to be able to work in a realistic listening situation in a concert-style environment. Concerts enable listeners to focus on the music in the absence of other distractions, such as uncomfortable seating, the sound of passing traffic, or the disturbance of phone calls. *Fuzzy IDEAS* is most useful if implemented to encourage focussed listening as an abductive activity, thus allowing ideas to emerge at various stages of the analytical process.

The listening observations document any possible features of music that occur to that listener as significant, as well as how that listener and analyst make sense of the experience. The documentation needs to be free enough to capture any type of conscious response, whether technical or ideational, as well as having the capacity to capture any available details of those sounds that are partially obscured from conscious awareness⁶. The method needs to be able to work with many different sound types and presentation methods. The method must be able to capture how the effect of music is more than the sum of its technical elements. The method must be available to all sorts of music, which can be done by using everyday words to describe aspects of the music rather than the technical numbering systems derived from various music theories. The new method needs to be able to capture and work with subjective experiential information, which explicitly includes time. This recognises that music is not a static object, and that making sense of the experience of that unfolding stream of sound, is a process that takes time.

Focussed listening occurs when listeners are doing nothing else than paying attention to the music: they are not dancing; they are not shopping; they are not doing housework, nor writing a thesis. As Clarke observes, conscious attention can rapidly move “...from great breadth and diversity of awareness, to...being absorbed in a singularity...From being aware of the whole concert hall experience with seats and coughing, to being completely absorbed in the sound of the music” (Clarke, 2005:188). Boulez concludes that focussed listening to music involves a researcher’s attitude towards the music, so that despite “...feeling unnatural, [yet] for the sake of personal development it must be investigated to find out what permanent value it might hold” (Boulez in Deliege, 1976:29). However, listening to

⁶ As discussed in Chapter 5, Section 5.1.b (see pp. 171-172) these Partially Indeterminate Events arise for many reasons attributable to compositional design of the music as an unfolding process over time, rather than specific difficulties in naming the content, or differences in aural skills training of listeners.

new music in a concert situation, where rewind is not possible, limits what is possible on this single 'take'. As Spitzer notes, not everything can be perceived on a single listening because there are limits on human cognitive capacity (Spitzer, 2004:344 (Chapter1, note 6)). As Lesaffre, De Voogdt et al. demonstrate, a broad cross-section of 21st century listeners find it difficult to describe art music in general, and their descriptions are extremely variable, even when they are highly familiar with the music (Lesaffre, De Voogdt et al., 2008:699). Thus, the documentation of the listening experience is likely to be quite limited.

Concert-style listening implies that the listener has no knowledge of the work beyond its title, and possibly composer, as this is the minimum information presented to concert goers on promotional materials. Any other information regarding the music requires background preparation by the listener, even if this is limited to reading program notes in the concert hall. While ignorance on background information might not be always true when listening in concerts, or to recordings, prior knowledge of composer and compositional period does not always translate into knowing a specific piece of music. What is perceptually noticeable in one piece of music is not necessarily related to other music by this composer, or other music from a similar time period. Indeed, as Krumhansl has demonstrated, even repeated listening by trained listeners to a specific piece of avant-garde music, does not mean that the music is 'known': the music does not become predictable, or can be recalled on request (Krumhansl, 1991:401). Treating each piece of music as new, namely that this is the first hearing of the music embeds the concept of the subjective listener into the new strategy.

Recordings, rather than live performances, should be used as the means of presentation, as this will give an even playing field to computer music as well as acoustic music. In addition, recordings make it possible to more closely replicate the listening experience with other listeners. As discussed above (see pp. 122-124, and in Chapter 2, see pp. 71-75) performers mediate the composer's music as denoted by a score or other performance instructions. Hence, using the same performance provides more direct comparison between responses. However, as stated previously, the music will only be listened to once through as in a concert situation.

Recorded music allows relatively accurate notation of clock time from CD players, but the subjective experience of time is documented in *Fuzzy IDEAS* along with other Reflective Events. Whalley notes that the personal experience of time will impact on the perception of, and the attention that the listener will give to, the music, and that this personal experience can be noted as one possible aspect of the impact of the music. However, it is not the only possible dimension that impacts a listener, as their primary perceptions may be seeing the music as a set of timbral colours, and it may not even be the way that those colours unfolded over time that made the timbre significant (Whalley, 2000a:213). However, Whalley does not go into the relation of personal experience of time to actual time passing. If the subjective experience of time is important to the analyst's experience of the music, then it can be documented along with other 'psycho-acoustic ideas'⁷, which in *Fuzzy IDEAS* are one type of cognitive event, termed Reflective Events. As will be discussed below in Section 4.4, capturing cognitive responses through Reflective Events is an important component of *Fuzzy IDEAS*.

Having explained the method for collecting information about a single listening experience in relation to my specific research question of explicitly using the real time sound of the music in analysis, the next section addresses the second part of my research question regarding the inclusion of subjective idiosyncratic personal responses to the sound of the music as it unfolds.

4.4 Auto-ethnography: Embracing the Subjectivity of Listening

This section provides an overview of auto-ethnographic research methods as ways of dealing with subjective research. "...I detest...those critics who take personal impressions as a basis for objective judgments" (Deliege, 1976:53). Yet what else can the listener or analyst do? As Judith Becker argues, it is important that musicology embraces aspects of scientific and qualitative methods of the humanities because "if we accept that culture determines responses then we abandon the idea of human nature as generalisable, but if we reside only in general principles we lose

⁷ 'Psycho-acoustic ideas' (Whalley, 2000b:154) encapsulates the concept of a composer translating an idea into music, which is then perceived by listeners and translated into thoughts, feelings and body responses, i.e. psycho-acoustic responses, which in *Fuzzy IDEAS* are called Reflective Events.

sight of individual behaviour” (Becker, 2010:132). This section explains why it is important to consider the background of the listener, document the self-reflective aspects of the listening experience, as well as the listener’s ideas about the music that arise before, during and immediately after listening. Finally, it is important to document any issues that arise while collecting the qualitative listening observations and during analysis.

The composer suggests ideas through music, not only through choice of constituent elements in the music, but also through crafting what is to stand out during the listening experience. *Fuzzy IDEAS* is designed to suggest compositional ideas grounded in information arising from a single listening experience through the documentation and analysis of ‘qualitative listening observations’.

Qualitative listening observations are documented as the music unfolds in real time, when the listener notices something in the sound of the music, or in their response to the music. These qualitative listening observations include any type of aural or cognitive occurrence that attracts or focuses the conscious attention of the listener. These could arise from a broad range of possibilities, not only in what may be considered the typical expressive attributes of Amplitude and Tempo, but also a change in Texture or Sound Source, or a complete Silence, or the presence of an unusual rhythm or grouping of events. Qualitative listening observations can also be an awareness of continuation, or an absence of something previously present. The documentation of the qualitative listening observations, due to physical limitations in information capture, and their later conversion to fuzzified data, necessarily only includes those aspects of the sound event that stand out sufficiently to attract the attention of the listener. Hence, each qualitative listening observation is likely to be an incomplete description of everything occurring in the music at that moment, but rather contains the significant aspect(s) of the sound(s) at that time to that listener. For example, this qualitative listening observation⁸ “5’25” - I have become aware of an unusual event where many different notes are being played nearly simultaneously, rapidly moving from one to another texture in a motion which did

⁸ This actual qualitative listening observation is documented in Table A.1. *Scharlachrote Buchstaben*: List of Cognitive Events (see p.281), and is used again in Chapter 5, Table 5.2 Example Coding of one Sound Event (see p. 176) to demonstrate how the coding taxonomy works in practice.

not sound random or chaotic, but rather as a swirling directed mass of sound“ directly includes texture but does not refer to amplitude, articulation, or register.

The time points of qualitative observations are also documented through noting the elapsed time from the beginning of the music to the time point of each qualitative observation as it occurs. In the later stages of *Fuzzy IDEAS*, all fuzzy attributes and features are charted at these time points across the time domain to give a visual representation of the music. This reveals the ‘temporal design’⁹ perceived by the listener, which results from the accumulation of noticeable events as they are recorded from moment to moment during the information collection.

During listening the actual points on the time-line are not predetermined, but evolve as the music unfolds. This time-line is not scaled, but simply records the times at which the other observations were made. The time-point of any qualitative listening observation is not fuzzy because a CD time counter can add precision to the observed clock time and consequent duration of events. Similarly, listening on a computer can accurately mark the time of a qualitative listening observation. This is not to disregard the latency inherent between observing something in the music and looking at the time counter. However, this latency is assumed to stay constant throughout the listening experience for all type of qualitative listening observations.

This timing information is used to explore how the perceived arrangements and inflections of the attributes of music into a formal design suggest an idea. It is unimportant whether this design is memorable, or can be consciously recalled. Listeners may be competent at noting the actual state of affairs on the surface of the music¹⁰, with all its ambiguity and uncertainty, and identifying the overall trajectory while listening. However, as Rowe argues, most listeners cannot hear the underlying structures of the music because they are too often obscured by the surface detail of the music (Rowe, 1993:204). To avoid any problems at this level of perception, and to maintain transferability, it is better to document time points for the qualitative

⁹ ‘Temporal’ in this sense refers to the time domain, a linear representation of the sequential passing of time, not to be confused with any notion of making the ethereal nature of music more worldly, although in some sense this is the purpose of charting the listening experience: to render the invisible audio stream visible.

¹⁰ The term ‘musical surface’ refers to the unfolding features of the music which are available for immediate auditory perception such as repetition of events, registral change, amplitude, texture, timbre, duration, and density of events.

observations so that the underlying structure can be investigated by later analysis of the visual representations.

The information for *Fuzzy IDEAS* is derived from the listening experience as the music unfolds through real time, along the lines of J.K. Randall's poetic paper on the unfolding experience of listening to music *A Soundscroll* (1973). Allan Moore also contends that meaning in music depends on detailed attention to the difference between related sounds (2003:15), which emphasises the 'sound' events, and their relationship to each other, rather than the score, and also that 'sound' has various qualities beyond pitch/melody/harmony. This also emphasises the importance of the listener in perceiving those relationships and sonic qualities, and then interpreting the collection of sounds as a whole into music. "Listening [i.e. the actual aural experience of the music] is a way of knowing the music, and that the "recognition or acknowledgment, and articulation" of the content of one's musical experience is integral to the process of understanding that experience (or as, itself, one kind of understanding)" (Hirata, 1996:27, note 29).

However, in conventional music analysis, analysts may teach themselves to listen for analytical devices, such as identifying functional harmonic progressions by type, which were originally developed to explain compositional technicalities, rather than listening for what actually exists in the sound itself. This process of analytical listening for technical identification is even more problematic because it brings what is happening behind the scenes to the foreground, so that what are tools for explaining the objects of our perceptions become the objects of perception themselves (Hirata, 1996:16). Catherine Hirata also uses the metaphor of magic to express her concern that this type of technical analysis may reveal how the music is created, but does not reveal "the magic that exists in the sounds" (Hirata, 1996:20). Perhaps this conceptual deficit is attributable to the Western way of thinking about mental processes¹¹. Further, as Ellen Langer, a psychologist researching

¹¹ As described in Chapter 1 (see pp. 48-49), psychologist Russ Harris observes that most people in the Western world have little or no concept of the 'observing' self (Harris, 2007:78). Therefore, it is difficult for Westerners to distinguish between the observing and thinking parts of perception. Consequently, this distinction has not become part of the mainstream thought processes of the disciplines of philosophy, psychology or particularly, musicology.

mindfulness and decision-making observes, typical approaches to decision theory¹² do not incorporate any reference or weighting for novelty or surprise because it is so difficult to capture the unknown in mathematical formalism, hence analysis is confined to speaking of well-known and well-defined events and event types (Langer, 2005:223 note 10). *Fuzzy IDEAS* aims to deal with these issues by collecting any technical information about the music, the listener's experience of the music, and their reflections on the experience, that can be noted down while listening. This collection method may be unusual in music analysis but is useful and plausible.

Conventional analysis attempts to obtain 'objectivity' by using the score as if it were the music, possibly because the score records pitch and pitch related events very well. Using a score for the basis of analysis enables checking aural responses against some pre-existing documentation reinforces the focus on pitch as the only material in music to be analysed.

The implications and difficulties inherent in using listening as a method of data collection range from limited information to the impact of technology, the impact of performers, variations in human perception, and, finally the listener's and analyst's subjectivity. The inherent individuality/subjectivity of the aural experience has been problematic for conventional analysis. However, the ideas suggested by music depend on what the composer wants to communicate AND how effectively the idea is communicated. A listener's cognitive awareness and perceptions of feeling/sensation can provide insights into the ideas which inform the music.

Fuzzy IDEAS is designed to capture the technical context and the sense-making decisions of a listener as they experience the music. The sense-making decisions are entirely free-flowing, being "...governed by...a sense of the situation in which you are located at that time (Langer, 2005:102)." This decision-making is based on internal individual psychological factors, so that if one choice 'feels' better than another then that is the choice to be made. This intuitive choice is an alternative to objective analysis, which, as Langer observes, requires endless hunting for information; hence

¹² Again, musicologists generally do not directly refer to theories of decision-making, nonetheless analysis is entirely a decision-making process, which can therefore be theorised.

it is impossible to know when to stop searching (Langer, 2005:217-221). In reality, the extent of search is often determined by practical considerations of time or money, so that the limits to the input are determined in a somewhat arbitrary way, which inherently limits the supposed 'objectivity' of the experiment. Therefore, it is more transparent to observe and document the decisions as being intuitive.

The new method aims to make sense of individual pieces of music based only on the incomplete descriptions of the music as documented during the listening experience. D. Stowell, A. Robertson et al, researchers in digital music, software engineering and machine learning, have written about evaluating human computer interactive performances and how to do it effectively (Stowell, Robertson et al., 2009:960). They point out that evaluation methods can and must still be rigorous, despite being applicable to small sample sizes (2009:961). Indeed, they see the necessity of being able to record the subjective experience of the task at hand because it is the experience of the interaction which is being evaluated, and that experience is, by its nature, subjective (Stowell, Robertson et al., 2009:962). These authors are comfortable with small sample sizes and subjectivity, recognising that these impact on the recorded data. However, a rigorous methodology can explicitly take these factors into account while still producing worthwhile results (Stowell, Robertson et al., 2009:962).

Fuzzy IDEAS is designed to record the listener's thoughts and feelings in response to this music. Milicevic proposes that a necessary part of the composer's job is to engage "the designated public...with an active, reflective perception" (Milicevic, 1998c:34). The purpose of observational notes is to capture, albeit partially, the stream of consciousness going through the mind of a listener as they experience the piece of music. The notes that are taken will be highly personal and idiosyncratic text, which vary from a single word up to a sentence in length and might be descriptive or emotive in content.

Fuzzy IDEAS is designed to explicitly incorporate the subjective nature of the music experience. There are commonalities to being a part of humanity, based in biology or cultural learning, which are relied upon in any form of communal activity or active communication. Yet individual listeners have their unique physical and mental capacities and relationships with other listeners, musicians, analysts, and

composers, as well as the world. Each of us in our own way responds to music, and one person's response is no more or less valid than any other individual's response. Any discussion about music must hold/contain these truths if the discussion is to be relevant, useful or meaningful.

Subjective, individual response is a fundamental condition/state of the listening experience. As Vella observes, subjectivity is present even in 'educated' technical, analytical listening in a concert situation because, even at the most basic acoustic level, two people in the same room will not physically hear the same sound because they are in different locations with respect to the sound source (Vella, 2000:30). There will also be individual differences in musical perception, such as the ability to separate, decode and group sounds into broad categories relevant to either technical descriptions, such as melody or bridge passages, or to sense-making categories, such as 'useful', 'useless', 'meaningful' or 'meaningless' (Vella, 2000:38). These differences will impact on that a listener's experience of music. It is impossible to eliminate subjectivity¹³.

If it is impossible to eliminate individual and therefore subjective responses, then it is better to openly consider the impact of the music on the listener as part of analysis. As Allan Moore spells out "people choose to experience music in order to have the experience of the music...they listen to it for the experience of listening" (Moore, 2003:6). Rather than considering all the extra-musical aspects, such as identity formation, that impact on listening choices, analytical questions pertinent to the music itself are "why was the experience of this piece of music like it was?" and even "why did the music sound like it did?" (Moore, 2003:6). Moore suggests that these simple questions give rise to subsidiary questions: "how does it sound?" and "why does listening to this music by the audience matter to them?" (Moore, 2003:6). These questions are significant because they emphasise how the music sounds and

¹³ Even machine-listening incorporates subjectivity of analyst. Some researchers, such as Cope are aware of this when he observes in relation to his digital analytical engine "EMI expects phrases to end with a cadence, but where and what is considered a cadence is user-defined, because in music identifying the cadential points, is often a matter of choice as they are not always clearly identifiable" (Cope, 1996:63). Other researchers assert the supposed objectivity of automated digital analysis of music files (see Chapter 4, footnote 15, p. 140), yet their automated research retains subjectivity because it is still these human researchers who determine what the machines will listen for, the way the input data is manipulated when setting cut-off points, and sampling methods. For example, Quinn (1997:256), Jehan (2005:113), and Serra, Corral et al., (Supplementary Information, 2012:5) each spell out how they set their thresholds according to their [informed] personal judgement.

the impact of these sounds on the listener, which is the primary purpose of *Fuzzy IDEAS*. These questions not only bring listening into the foreground of analysis, but they also indicate that bringing descriptions of the sound of the music together with the audience reaction is worthwhile and necessary.

The ability and importance of the audience in evaluating music is recognised by Stowell, Robertson et al., when they suggest the evaluation of algorithmic composition engines through a “discrimination test”, analogous to the Turing Test¹⁴ (Stowell, Robertson et al., 2009:965). Although, as Moore observes, typically listeners are “...encouraged to conceptualise the invention of music as a branch of magic, to believe that musical actions and gestures cannot be subject to any level of explanation, and hence understanding, beyond the trivially biographical...” (Moore, 2003:6-7), at risk of stating the obvious, this type of discrimination test is not possible unless an audience is present and their opinions are valued.

The deeper questions regarding audience evaluation, or the impact of music on listeners concerns the type of evidence that enables useful conclusions to be drawn. Although statistical theories indicate that results taken from a small number of respondents are not very reliable, some researchers choose to work with small sample sizes because this enables the collection of an open-ended range of qualitative information that can “...reveal aspects of user’s conceptualisations...” (Stowell, Robertson et al., 2009:972). Leonard Meyer (1956) quite happily developed his theory on how music generates emotion without troubling about what other people thought. He made an argument to support those opinions and assembled score-based evidence to support his proposition; however, he did not test these theories on real listeners. It is not even clear if he tested his theory on himself.

There is some discussion in the literature about objectivity and subjectivity in relation to music. For instance Mladen Milicevic suggests that there are no objective aspects of music as “...humans come loaded with subjective experiences...these must impact on their meaning making (Milicevic, 1998c:27). There may be an attempt at being a non-judgmental observer. However, this falls back to the individual’s

¹⁴ Applying the Turing Test, requires asking the audience if they thought the music they were listening to was composed by a human or a computer. Stowell, Robertson et al., note that this test has been used by several researchers into automated music composition (Stowell, Robertson et al., 2009:965).

capacity to perceive in a physical sense of ability, and mental ability of insight and awareness. The listener's previous education and learning about the subject may bring awareness of what the artist has contributed to the work, how much effort might have gone into this work, as well as provide the language to be able to talk about and discuss the work and its effects.

Perhaps music criticism could openly include self-reflexive remarks thereby allowing the subjective impacts of the music to become transparent. Kyle Gann, a composer and critic, suggests that music criticism could become 'objective' if critics acknowledge the degree to which they are affected by the music and explain their perceptions of why they believe this affect has occurred (Gann, 2011). Self-reflexive reporting recognises that subjectivity is inevitable as "...there are no autonomous people, there are no autonomous data, analyses or pieces of music" (Walser, 2003:38). As Moore acknowledges "By subjecting this sound to analysis, we are in fact making an interpretation of the relationships apparent between it and antecedent, simultaneous and consequent sounds, an activity into which it is impossible not to insert the self..." (Moore, 2003:8). Walser simply asserts that "Musical judgements can never be objective, but can never be dismissed as subjective" (Walser, 2003:24). As discussed below (see p. 142) Guck demonstrates that even with formalist analysis, the subjectivity of the analyst is still revealed by the way they write (Guck, 1997; Guck, 2006). Robert Walser says that the closest one can get to objectivity in this situation is the ability to keep one's mind open, with the desire to understand how individuals can share meanings. His solution is that subjectivity needs to be out on the table through "...a conception of analysis that is self-reflexive about methods and goals, tactical rather than absolute." (Walser, 2003:38) This confusion between rigorous methodology and objectivity is maintained by many researchers¹⁵.

¹⁵ Some programmers like to suggest that machines are supposedly impartial, by using descriptions such as "...bias-free system has been given generic listening and learning primitives, and was programmed to analyse the sounds and structures of music uniformly from the ground up" (Jehan, 2005:113). No matter that human intervention has occurred in designing the system, and deciding what music to use as input data for which the system is then designed. For instance, Jehan's method of audio compression retains only one representative segment for each data cluster. The selection is made by testing all the data against a threshold of perceptual similarity. "The ideal threshold is theoretically a constant value across songs, which could be defined through empirical listening test with human subjects, [but which] is currently set by hand" (Jehan, 2005:94). This pre-analytical data manipulation clearly has human input, therefore, logically the data is still possibly biased. However,

Rigorous methodology does not necessarily lead to objective, or logical conclusions. For instance, researchers into artificial intelligence and complex systems in relation to music, Joan Serra, Alvaro Corral et al (2012), offer the results of what they describe as an ‘objective’ analysis of popular music over the period 1955 to 2010 to see what has changed and what has stayed the same. Their analysis is based on processing a database of nearly 460,000 recordings of songs that span a variety of popular styles, including rock, pop, hip hop, metal or electronic. Each beat of each song has coded information supplied by the database owner on style, pitch, beat, timbre, cultural information and loudness among other things. These vast quantities of information have been used to analyse by “exploiting tools and concepts from statistical physics and complex networks” to find the most common transitions in “the general usage of pitch, timbre and loudness in contemporary western popular music” (Serra, Corral et al., 2012:1) Although Serra, Corral et al. see their work as significant because “With the present work, we gain empirical evidence through a formal, quantitative, and systematic analysis of a large-scale music collection” (Serra, Corral et al., 2012:5), yet the inherent subjectivity of any research becomes evident in their conclusions.

Serra, Corral et al., take their results as a basis for subjective speculative conjecture when they suggest that “...our perception of the new [in popular music] would be essentially rooted on identifying simpler pitch sequences, fashionable timbral mixtures, and louder volumes. Hence, an old tune with slightly simpler chord progressions, new instrument sonorities that were in agreement with current tendencies, and recorded with modern techniques that allowed for increased loudness levels could be easily perceived as novel, fashionable, and ground breaking” (Serra, Corral et al., 2012:1-2). However, this conjecture is not the only conclusion to be drawn from the analysis provided. A plausible alternative is that the evidence points to a narrowing of what is considered ‘normal’ through pressure to tweak products to make them saleable because strategic marketing has also been increased over that time, as perhaps have other variables external to the sound of the music.

Jehan happily asserts that “...the machine is...not biased like humans are. Those differences account for the usefulness and potential of computers in creating new music” (Jehan, 2005:117).

Duncan explains that qualitative research methods, which reflexively include the researcher, have become accepted scholarly tools in the late 20th century (Duncan, 2004:30). The first edition of *The Handbook of Qualitative Research* was published in 1994 and is now into its fourth edition (Denzin and Lincoln, 2011). Qualitative research methods address research problems that inherently and necessarily incorporate personal experiences by using carefully designed techniques to acknowledge the presence and actions of the researcher, while producing valid and reliable research results. These auto-ethnographic research methods are rarely explicitly used in musicological enquiry, even though music analysis, despite its best efforts to achieve objectivity, is necessarily subjective.

Auto-ethnographic methods could be a fruitful addition to musicological scholarship. As Guck argues in music analysis “...stories of involvement are unavoidable, [so] each of us needs to consider what story to tell” (Guck, 1994a:230). She notes that stating the research methods and goals are important, while the actual language used in analysis does not have to be scientific, as long as it is used thoughtfully and carefully through the “...explicit connection of interpretive attributions with observational language” (Guck, 1997:54). Although auto-ethnography is not named explicitly, Guck applies the careful methods of auto-ethnography in her approach to studying music by reversing the focus of music analysis from the structural aspects of music to instead “...provoke readers to examine the relationship between analyst and musical work” (Guck, 1994a:230). Guck concludes that this reversal allows analytical interpretations to become inter-subjective¹⁶ while working with one’s personal impressions of the music (Guck, 1997:55), with the added benefit of improving one’s hearing awareness of the music and noticing more about the sound of the music (Guck, 1997:55). As Guck demonstrates, the language used by each analyst reveals their individualised perspective as they tell the story of the music (Guck, 1994a:218). Therefore, it is necessary to make the following statement about my background as this informs my reasons for, and approach to, *Fuzzy IDEAS*.

¹⁶ ‘Inter-subjective’ refers to the phenomenon whereby a specific subjective experience is comprehensible to other individuals studying specific music. Even if other researchers do not have similar subjective responses to the specific music, they can understand what prompted the original listening response.

My Personal Auto-Ethnographic Statement

As described in the Introduction to this thesis, I am a composer interested in avant-garde music. This means that I have insider knowledge of techniques, technology, composers, and music organisations, and am really interested in the design of music. I am a 21st century composer who has been taught to not to rely on functional harmony as the sole driver of music. My interest in composition brings an intense awareness that every aspect of the sound of the music is part of the design of the music because all aspects of the sound of the music is available to compositional influence, at least to some degree. Further, that every aspect of the sound of the music influences my personal response and, thus by extension, that of other listeners, whether or not they are consciously aware of it. I also wonder, apart from those endless aural exams, how many people really do listen for ‘form’, or use any insider knowledge and listening prowess gained from music training¹⁷. I am aware, however, that my background gives me a particular approach to listening and discussing the experience of music.

I listen for the experience of the whole of the sound of the music, not listening for ‘form’ so much as enjoying the return of something familiar in the sonata recapitulations. Rather than listening to classify chords and harmonic progression, instead identifying the high piccolo line floating over the top of the storm in Beethoven’s 6th (*Pastoral*) *Symphony*, and how that lone sound cuts through the density of the rest of the instruments, but also how the shrillness adds character to the chaos of the orchestral storm. I enjoy familiar music I have heard many times, the standard popular ‘classical’ orchestral repertoire, with melodies and harmonic movements that for some reason do have huge emotional impacts or bring a sense of closure at the end of a symphony. But I also seek out and value the unusual, especially if the results are as spell-binding as the old warhorses, and sometimes they are.

I particularly look for what new technology can bring to music that is different, that opens up a capacity that composers and music did not have before. For instance,

¹⁷ In fact Konecni’s research into the relationship between music and felt emotion, shows that of 166 psychology students, only 4% engage with music solely for the purpose of analysis or even simple contemplation of technical aspects of the music (Konecni, 2010:699).

Sethares' new tuning systems enable synthesis of harmonious music from unusual sounds (Sethares, 2005). Then there is new electronic music that pushes the boundaries by incorporating dimensions nearly impossible with conventional acoustic instruments. For instance, *Móvil II* (Enriquez, 1969-72), which is music composed from the sounds produced by a solo violin, yet presented through headphones. This enables the use of stereo space to simultaneously put one sound event, often a single note, but sometimes a distorted motif, in each ear and one apparently in the middle of your head. This music could not exist in its present form without 20th century technology.

It is hard to know exactly what difference this delight in sound makes except that, as a trained musician, I have heightened aural ability to identify 'objects' or features and attributes of music, and then to name them in particular ways that reflect my theoretical training as well. This means I tend to listen analytically and technically, to absorb details of the music as an important part of my experience of the music. However, I tend to vague out if there is not enough 'momentum', or too much repetition within the music. I found it a very interesting exercise for my MCA-R degree to listen to more than sixty pieces of electronic music on CDs by reputable publishers and discover that some pieces held my interest for more than twelve minutes before my attention began to wander, while other music held my interest for three seconds or less. To this extent, I sympathise with the broader public who seem to dislike avant-garde music. This experience led to my curiosity about how I could make music that would encourage people to want to listen to find out what was going to happen, or to get some kind of response and understanding of the ideas I attempt to communicate through my own music. My questions started with why different music led me to respond differently at least in terms of attention span, still potent as reflected in this research for this thesis.

4.5 Fuzzy IDEAS: Stages 1-4 of the Method Explained

The method of information collection and analysis that is *Fuzzy IDEAS* is outlined in Table 4.1. The Stages of *Fuzzy IDEAS* (see pp. 119-122 above). The following sections will explain the systematic work flow used in each of the first stages of *Fuzzy IDEAS* in more detail. These stages collect information about this individual

experience of listening to the piece of music, as well as initial abductive hypotheses made by the listener about a possible story/idea which makes sense of the music.

Stage 1. Documenting Pre-Listening Pre-Conceptions

Auto-ethnography part 1. The first stage, before listening to the music, is to observe anything that could colour the listener's initial listening responses, including conscious consideration to the possibilities suggested by the title. Conventional musical analysis does not focus much on titles, but *Fuzzy IDEAS* assumes that composers give their pieces a title to frame the listening experience and guide the listener into the music. The listener also documents any insights or expectations of what they are about to hear based on their prior knowledge or experience but without examining any additional background materials such as program notes or concert programs. Their existing knowledge may include any information or preconceptions about the composer, the style of music, the manner of presentation, or any other thoughts or expectations of what they are about to hear. Stage 1 documentation can include specific expectations of the music as well as images or thoughts the title brings to mind.

Stage 2. The Qualitative Listening Observations

After considering the implications of the title and other information or preconceptions of the music held by the listener, the music is listened to from beginning to end in one sitting only, while noting qualitative listening observations in the moment with pencil and paper, or personal digital device on a time line. The listener documents any aspect of their listening experience, in writing, while the music is playing. The listener writes down thoughts, impressions, memories that cross their mind while listening, as well as details of the sounds they are hearing. This documents the listener's real time perceptual and cognitive responses. These observational notes can be taken at a live performance or while listening to a recording. It is recommended that notes be only taken once, on a single listen through, to simulate the concert experience.

Listening observations are a qualitative description of what is happening in the sound of the music at those moments when the music has caught the listener's attention. The description may use music symbols as a shorthand, such as < for

gradually getting louder, or it may use music-specific terminology, or it may be any other portrayal of the music that comes to mind at that moment. The details noted will not necessarily be consistent from one event to the next, as any facet of the music can focus attention. Professional musicians may occasionally have music-specific terminology for what they hear, such as *diminuendo*, and may be able to conceptualise how details in the music occur, for example being able to name a sound type as *clarinet*. However, this does not alter the basic aural reception of the sound, what it does affect is the way the sounds of events of that music are conceptualised and named.

Reflective Events are used to document any problems arising while collecting the qualitative listening observations, such as the inability to describe what is happening in the music, or the noticing of difficulties in discerning aspects of some sound events. Reflective Events may also refer to the personal experience of time which results from listening to this specific music. Reflective Events can document the role of changes in the sound of the music in affecting listening responses. It is certainly possible that reactions to subsequent events are partially determined by the nature of the events that have preceded them. Some thoughts may be self-reflective on the listening experience itself, while others may be instantaneous/spontaneous recognition of some feature in a sound event, while other Reflective Events may be a more considered reflection on the possibilities presented by an individual sound event, or group of events.

As mentioned in Chapter 1 (see p. 48) Russ Harris defines two parts of the self, and their functional difference: (1) the ‘thinking’ self and (2) the ‘observing’ self (Harris, 2007:77-78). Harris goes on to remark on the interaction between the two parts of the self that tend to be mutually exclusive. “If you are truly...riveted on the object of focus, there is no room for thinking. If the observing self pays too much attention to thoughts, then the focus is lost and then performance of the task is impaired, as direct contact with the object is lost” (2007:78). Reflective Events record any of these aspects of a listener’s reception and cognition as the listener moves from one state to another.

Some Reflective Events may simply describe the attention state while listening and if there are any thoughts about the music occurring at those times. On some

occasions, it is possible that an attention state, rather than a specific event in the music, triggers a thought event on the time-line. Possible Reflective Events include awareness that attention slides off, noted as a thought state of 'boring', or, for example, when very attentive is noted as a thought state of 'this is very interesting'.

Because *Fuzzy IDEAS* is designed to elicit possible ideas the composer may be communicating through this music, Reflective Events are included to document how the music produces defined cognitive responses¹⁸ at specified times during listening. 'Reflective Events' capture subjective experiential psycho-acoustic responses. Examples of psycho-acoustic responses abound in music discourse. For example, statements that Mahler's music is popular because listeners are able to identify themselves in the music and feel "I have suffered too", or Beethoven's music which expresses a philosophy of existence, of life, of the world, which goes beyond suffering (Meacham, 2010). Earlier, Scholes concludes that even Absolute Music¹⁹ "...is capable of having a story or series of pictures read into it by the imaginative listener..." (Scholes, 1970:836-7). These comments suggest that psycho-acoustic responses are an important part of the listening experience.

Qualitative listening observations note what the listener is perceiving and thinking about as they listen, captured while the music is playing. Time in listening to music is itself a fuzzy concept. If one is interested in the music then time flows by, and if one is bored then time is stagnant. Yet the utility of the visual representations in engaging with the compositional design requires that time be measured as accurately as possible. This ensures there is common understanding between people (composers, analysts, listeners) of what the music sounds like at time points, and provides very specific feedback to composers about the impact of their music in relation to time. It is difficult, while listening and notating qualitative listening observations, to have more than a fuzzy estimate of elapsed time. However, it is possible to observe actual time by using a clock time; either a stopwatch or a digital display, perhaps the digital counter on a media player, to create a timeline based on real time rather than perceived time.

¹⁸ This term is an umbrella term for documented events that involve thinking rather than sense perception. The usage is explained in the Quick Reference Guide: Glossary of Terms.

¹⁹ See the Quick Reference Guide: Glossary of Terms for definitional information on this music term.

Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience

Auto-ethnography part 2. Immediately the music ends the listener documents any initial impressions about how the music makes sense. These are ideas prompted by the activities in the previous two stages, and the lived aural experience of the music.

Collecting qualitative listening observations is unusual, but useful and plausible in response to asking 'How does the sound of this music make sense?' Cope explains that creative thinking requires 'free association' of ideas' (Cope, 2005:287), while Langer identifies the difficulty of capturing the unknown in mathematical formalism, with the result that analysis is frequently confined to speaking of well-known and well-defined events and event types (Langer, 2005:223 note 10). However, as Stowell, Robertson et al conclude, the explicit incorporation of individual responses "...in an extremely structured approach, clearly acknowledges that subjective experience is an integral part of user evaluation, to be considered and exploited, rather than being denied and discounted" (Stowell, Robertson et al., 2009). It is 'psycho-acoustic ideas' which turn a stream of sound into music.

This method of collecting the qualitative listening observations is a kind of compression algorithm which favours those sound events which are attention getting, while eliminating routine events. Listening to the piece of music straight through from beginning to end limits what can be noted down. The limits arise from the speed at which things can be documented in writing, as well as where the listener's attention is focussed at any moment so that some aspects of the music will be overlooked.

Importantly, this shifting listening focus of attention is a key feature of *Fuzzy IDEAS*. As Howard Becker explains, "...any [art]work has only those characteristics its observers notice and respond to on any particular occasion. Whatever its physical properties, they do not exist in the experience of people who do not know or care about them" (Becker, 2008:214). Another advantage of *Fuzzy IDEAS* is that it counts what has been noticed, not the events which have been remembered. Although remembered events may be important, memory is somewhat unreliable in terms of information gathering. Consciously noticed events, at least continue to remain subconsciously, even if not explicitly remembered after listening is completed. I

submit that the observed attributes and features of all consciously noticed events will impact on the perception of the music as a whole and how it makes sense. Therefore, the qualitative listening observations being descriptions of the actual music as experienced allows an underlying idea suggested by the music to emerge.

Stage 4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations

We apprehend the outside world, and have responses to it in several different dimensions: 'Thoughts' are words inside our heads, while 'Images' are pictures inside our heads, and 'Sensations' are feelings inside our bodies, such as the sensation of eating breakfast. Any of these activities come under the umbrella term 'cognition', the technical term which refers to any product of the mind, such as a thought, an image, or a memory (Harris, 2007:51-52). Yet "the boundaries of music cognition are not very well defined and the term should be used with great caution" (Jehan, 2005:35). Jehan adds that there is more to music cognition than the audio signal alone, including extra-musical influences such as the listener's "...concepts of music, culture, and emotions" (Jehan, 2005:35). Therefore, explicitly and carefully documenting the nature of the cognitive events requires more qualitative description, as well as providing insight into the researcher experience as required by auto-ethnography.

As the music is playing, the listener writes²⁰ a series of time-stamped, short, observational notes about their thoughts. These notes might include thoughts about how the music is affecting the listener, what the music reminds them of (including their own musical history), mental images that the music evokes, visceral reactions, wandering thoughts and so on. The amount of writing that is produced will depend on the capacity of the listener to listen closely and attentively, as well as depending on how engaged the listener is with the music and how quickly they can formulate responses and write at the same time.

²⁰ The qualitative listening observations could also be collected from listeners who are unable to write by using a scribe writing their remarks in real time, or by recording their remarks on an audio track that runs simultaneously with the music, which would be transcribed after the listening is completed.

Several examples from my listening to *Scharlachrote Buchstaben* are:

- 5'25" I have become aware of an unusual event where many different notes are being played nearly simultaneously, rapidly moving from one to another texture in a motion which did not sound random or chaotic, but rather as a swirling directed mass of sound.
- 6'00" The material is recognisable as having been previously heard, but is now at a higher Register. However, the onset of this material is unclear.
- 6'15" This observation is a time point check through the reflection that despite the previous change in Register, I was still hearing the same material, now for a long time, nearly one minute ago. Yet at this point the music was still aurally interesting, so I was also curious to understand why I was still engaged, which I decided was due to the rapidity of events and the continual variations.
- 6'25" The melodic line fades in and out of the accompanying texture, which can only be accompaniment if the melodic line exists.

For the sake of comparison, here are some qualitative listening observations of the same music during the same time interval, made by an untrained listener²¹.

- 5'25" Trial and error. Tightrope balancing act.
- 6'05" Taking steps.....Journey....Walking.....Timid.
- 6'40" Length of discovery....

These second set of qualitative listening observations underline the importance of Stage 4. These qualitative listening observations are cognitive events²² rather than technical descriptions of the sound. It is here in Stage 4 of *Fuzzy IDEAS* that the

²¹ This sample is taken from the evaluation performed as part of the evaluation of *Fuzzy IDEAS*. The evaluation is discussed in detail in Section 6.2 Evaluating Fuzzy IDEAS as Analytical Method (see pp. 215-228).

²² Documentation of cognitive events can contain information about self-awareness of perception, memories and reactions to the sound of the music; moments of focussed attention on the music; any moments at which the listener has become consciously aware that particular aspects of the sound of this music have stood out from the background, along with any technical observations that provoked those thoughts or insights.

qualitative details and quantised time-point²³ of each cognitive event are explicitly documented in the analysis. Explicitly and carefully documenting the nature of cognitive events in the analysis provides insight into the listener's subjective state of mind and their experience as required by auto-ethnography. Cognitive events include any insights regarding attentional state and what has brought that state into being. Cognitive events reveal the individual subjective experience of the music and implicitly, personal preferences about what the listener enjoys or dislikes about music and/or how open minded they are to new experiences. This explicit documentation of cognitive events also provides insight into how the listener is responding and making sense of the music as their thoughts rose to conscious awareness. Cognitive events, along with the time points of their occurrence, are documented in a text based list such as Table A.1. *Scharlachrote Buchstaben*: List of Cognitive Events (see pp. 282-284). When the cognitive events are tabulated the time-points are quantised downwards to the nearest 5 seconds, simply for ease of calculation in later stages of analysis.

However, it is important to note that this list of cognitive events does not include every qualitative listening observation, because not every qualitative listening observation is associated with thoughts and insights. Therefore, those qualitative listening observations that only include technical features of the music are not included in the list.

Stage 4 also includes information about any specific challenges or problems that arose while collecting the qualitative listening observations, for instance the use of alternate timing mechanisms, or the recording failing mid-way through playback.

Summation

The new method outlined and discussed in this chapter and the next is *Fuzzy IDEAS* (Fuzzy Inclusive Dialectical Expressive Analysis System). Setting out the method step by step means the method can be replicated by other researchers. There are several implications for the processes of this new analytical method because it is grounded in the liminal space between composition and listening. This reinforces

²³ Quantisation is explained in the Quick Reference Guide: Glossary of Terms (see p. xxvii).

the need to explicitly capture the subjective idiosyncratic personal responses to the sound of the music as it unfolds, and thereby enabling real time to be incorporated into the analysis. The chapter also includes a discussion about the need for an explicit auto-ethnographic approach to listening and analysis, since listening to any type of music is an aural encounter with sound in real time that can only be experienced individually and subjectively. More importantly, it is impossible to escape subjectivity in music analysis, because analysis is an interpretive activity, even though individual perceptual and ideational responses may vary widely.

This chapter is concerned with the first four stages of the method: preparing for and documenting the process of listening to the music, and making sense of music immediately after listening to the music. Chapter 5. *Fuzzy IDEAS: Applying Fuzzy Logic to Analyse Avant-Garde Music*, explains how this individual experience of specific music is converted into visual form using fuzzified versions of the qualitative listening observations. The resulting visual representations provide a transparent wholistic view of the music experience, which can be analysed through visual inspection of a set of analytical charts. This analysis aims to draw out any ideas suggested by this piece of music, along with the technical aspects of the music that have stimulated these ideas.

Chapter 5 explains how an analyst can systematically categorise a listener's personal experience of a single piece of music into fuzzy logic entities, and thus represent their experience graphically. In *Fuzzy IDEAS*, the listening experience is represented by a series of visual representations of different aspects of the experience, which are most meaningful when considered together. These visual representations are produced digitally, rather than with pencil and paper. The digital production of these visual representations facilitates the use of colour to distinguish related aspects of the categorised fuzzified data. However, the method is straightforward and is simple to manage, so it could be implemented by hand if desired. This unique, visual representation of an individual subjective experience of music can be used for various purposes in music analysis, in particular, for examining how a particular compositional design can suggest an idea.

Chapter 5. *Fuzzy IDEAS*: Applying Fuzzy Logic to Analyse Avant-Garde Music

The conversion process described in this chapter is an integral part of the wholistic, systematic, repeatable, and inclusive method of music analysis set out in this thesis. The whole process is designed to be transparently comprehensible¹ and straightforward to implement. The main body of the chapter is concerned with explaining the rationale for each stage of the application of fuzzy logic and the workflow so it can be examined and applied by other researchers. Readers interested in technical details of how the fuzzy logic principles are applied in practice within the coding taxonomy can find this information in footnotes to Section 5.1 Converting Qualitative Listening Observations into 'Fuzzified' Data.

In this chapter I will set out the coding method based on the principles of fuzzy logic discussed in Chapter 3, Section 3.1 (see pp. 94-98 above). The primary application of fuzzy logic in this thesis is in the manual classification of individual qualitative listening observations to produce fuzzified data in a consistent format. This classification process is the site of my innovative practical application of fuzzy logic.

In this chapter, I also set out the systematic process of mapping the fuzzified data to produce useful visual representations of a single experience of concert-style listening to avant-garde music. Consistency of format, and maintenance of detail enables this analytical method to be transferable to all types of avant-garde music. The aim of the conversion process is to produce visual representations that provide tangible evidence for assertions regarding how the sound of the music makes sense to that listener, and the ideas which possibly inform the design of the music.

Even though this coding and mapping is the most complex part of *Fuzzy IDEAS*, the resulting visual representations of the fuzzified data are easily analysed for patterns and unique events. Visual representations are a useful way of portraying complex information. By comparison, qualitative summaries of information that contains

¹ Transparency is a relative concept, but in this context, the method is transparent compared to mathematical formulae embedded in computer programs, or the arithmetic representations of some features of music in music theory and analysis, such as scale degrees, pitch classes, and chord numbering.

nuanced variations require so many qualifications and explanations that it is hard to produce a condensed version. Text descriptions of a complex experience can easily skim the surface of the experience to maintain readability or, if aiming to provide realistic detail, becomes convoluted and difficult to follow. Particularly, it is much more difficult to simultaneously represent the multi-dimensional nature of music in text or numbers². Mapping a listening experience into visual form can be an efficient and useful way of presenting information because a picture saves a thousand words, while even a score needs a thousand words to describe it, let alone the additional information associated with perceptual and cognitive events. Visual representations can be a useful way to present information about an extensive range of features in relation to significant factors such as elapsed time³. Presenting information in visual form permits also rapid analysis to find commonalities and differences between attributes and features of sound events, as well as the temporal structures determined by patterns of occurrence of specific sound events.

As discussed in Chapter 2 (see Section 2.2, pp. 71-75) music scores are an existing visual representation of music, but are inadequate to the task of representing music as a time-based process in several respects. However, as discussed in Chapter 3 (see Section 3.1 Value of Using Fuzzy Logic, pp. 94-98) fuzzy logic provides a new approach to information classification and data manipulation for problem solving that is eminently suited to this task. Using fuzzified data allows the visual representation to capture more comprehensive details about a range of attributes of the sound of the music, as well as the listener's ongoing individual subjective assessment of the music as it unfolds.

This chapter, Chapter 5, begins by describing my process for 'fuzzifying' the qualitative listening observations. Fuzzifying is the process of converting information, here the qualitative listening observations, into fuzzy logic entities by using a coding taxonomy. A coding taxonomy names the set of rules for translating any set of observations into a classification system, such as the fuzzy logic system I

² The cliché "A picture is worth a 1000 words" springs to mind here.

³ Other researchers using fuzzy logic to address problems in music who also used visual representations of fuzzy logic entities include the visual contours of membership functions of a group of feature sets (Cadiz, 2006a:71), and colour coding to reflect the degree of match between individual melody notes in performance and the score in four feature sets (Arcos, Gaus et al., 2013:69).

have developed and explained here in Chapter 5. A coding taxonomy is useful because it is clearly spelled out for other researchers and provides a consistent and systematic way of organising and categorising qualitative listening observations.

My fuzzy logic coding taxonomy specifies:

- what attributes and features should be included in the fuzzified data
- how to identify sound events
- the time points of sound events
- the way features and attributes relate to each other.

Conceptually, the taxonomy is based on the acousticians' definition of a physical sound object, in that acousticians have defined three independent attributes of sound as an object: time, amplitude and frequency, while as human listeners we know that a sound conveys cognitive information as well. Additional attributes are added to these four basic attributes as required to adequately classify an individual listener's observations.

My coding taxonomy specifies that attributes should be independent of each other as this allows for ease of visual analysis in later stages of *Fuzzy IDEAS*.

Independence of attributes permits meaningful⁴ visual analysis of each visual representation, while also permitting simple addition of the information in several visual representations to arrive at cumulative results so it is possible to draw inferences about the sound of the music which may not have been directly reported in the qualitative listening observations. Figure 5.1 below provides an outline of the process of classification, as well as the relationship between fuzzy logic entities.

The conversion of the qualitative listening observations to fuzzified data begins by converting the original listening observations into fuzzified data. A fuzzy logic framework ensures that features that contribute to uncertainty in the music are adequately described and maintained throughout data manipulation into visual form and the analysis that follows. Allocating the listening observations to high level

⁴ The visual representations are designed to be a transparent and meaningful mapping of the information contained in the qualitative listening observations. This arises when the information that you see is the relevant information, and the presentation directly correlates with what has occurred in real life. This contrasts with algebraic formulations, in which the processes are collapsed into and hidden behind (usually Greek) symbols, from which results magically appear in numerical form.

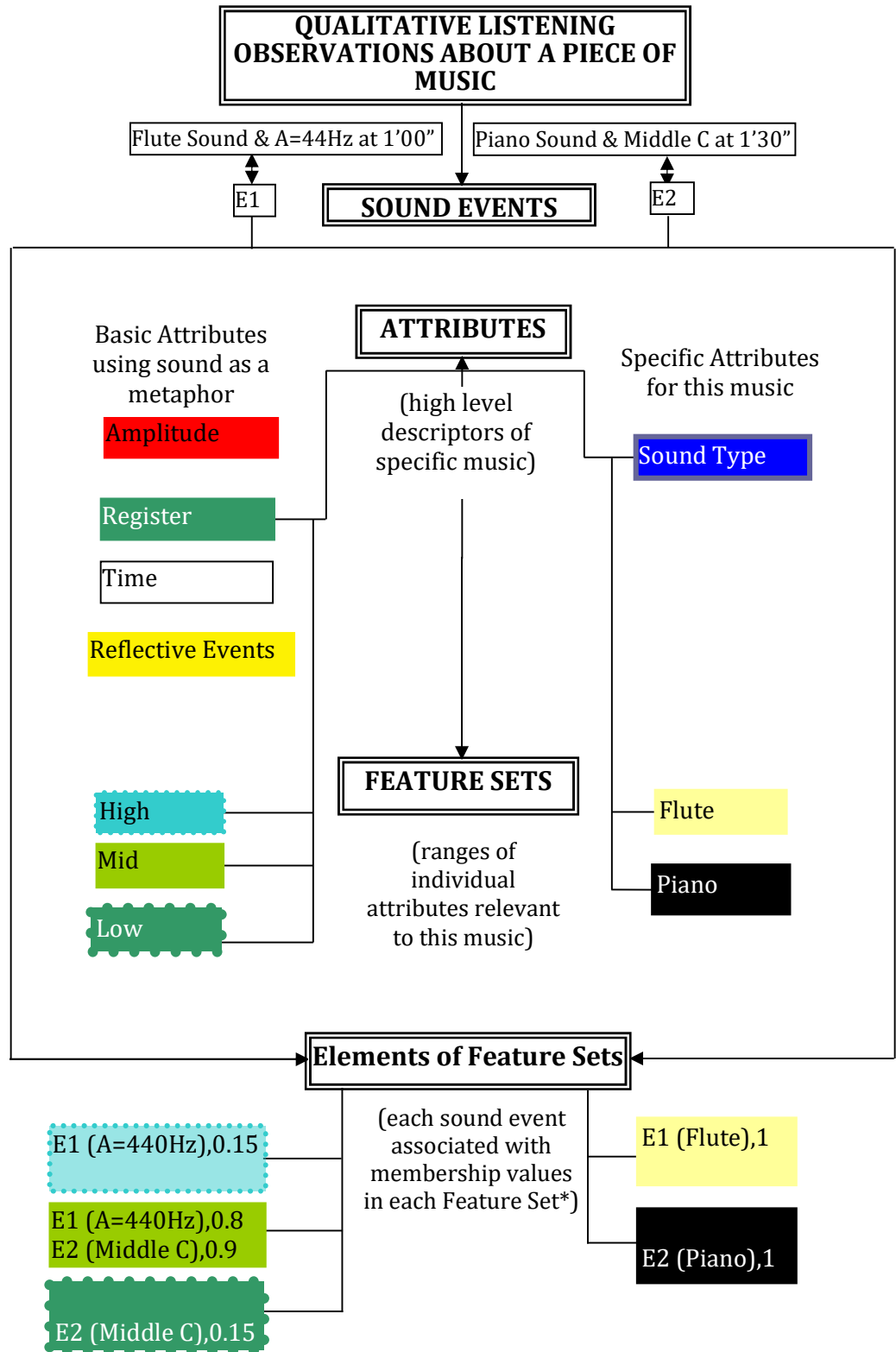
attributes implies that the precise nature of individual sound events will be lost. However, the fuzzy feature sets preserve detail about the qualities of individual sound events in relation to each other, and the degree to which each sound event is thought to belong to that feature set, through the addition of membership values.

The second part of the chapter is concerned with constructing and analysing the visual representations of the fuzzified data. The fuzzified data is initially presented in time series form, as a mapping of real time listening to the visual domain. Points considered here include:

- colour coding to consistently highlight similar detail in the fuzzified data across different listeners and different pieces of music
- the simultaneous capturing of subjective and technical responses about the sound of the music
- how I have resolved the problem of representing multi-featured events and relevant membership values.

The final part of the chapter describes the process of implementing these decisions into the final five stages of *Fuzzy IDEAS*. Firstly to produce the set of analytical charts, each of which addresses a single aspect of the information captured in the initial visual representations. There are two types of analytical charts: frequency histograms and time series, each of which provides information about different aspects of the compositional process. Secondly, the final two stages of the method analyse the information contained in the detailed visual representations of the listening experience. These two sets of analytical charts highlight the important qualitative and temporal dimensions documented for this specific experience of the music. Analysing the visual form of the fuzzified data is a type of memory recall. The visual representation reveals more than can be consciously remembered, because, as time passes, it is harder to mentally recall accurately what has occurred previously in the listening experience. Analysing the detailed visual representations suggests those aspects of sounds and their temporal organisation with which the composer was working while designing this music.

Figure 5.1. Classification of Qualitative Listening Observations into Fuzzy Logic Entities



*Following convention, sound event E2 is not mentioned in the fuzzy feature sets 'Flute' or 'High', because E2 is a Low Piano sound which means it has a membership value of zero in those specific fuzzy feature sets.

5.1 Converting Qualitative Listening Observations into ‘Fuzzified’ Data

The purpose of this section is to explain the coding taxonomy I have developed to classify the qualitative listening observations using fuzzy logic principles into a hierarchy of ‘fuzzified’ data¹. The conversion of the qualitative listening observations to fuzzified data is the most significant application of fuzzy logic in this thesis. A coding taxonomy is the set of rules to be applied to consistently translate any set of qualitative listening observations into a classification system, such as the system Serra, Corral et al, use to determine what data is to be categorised with particular codewords (Serra, Corral et al., 2012:4). A coding taxonomy is useful because it is clearly set out for other researchers and provides a consistent and systematic way of organising and categorising the qualitative listening observations into a hierarchy of fuzzy entities². The fuzzy logic system I have developed and am presenting here, is a similar coding taxonomy. My coding taxonomy shows the analyst how to organise and categorise the qualitative listening observations into each of these fuzzy logic entities. This coding taxonomy specifies how to identify sound events, the time points of sound events, the way features and attributes relate to each other, and what attributes and features should be included in the fuzzified data.

There are several issues involved in deciding how to classify the listening observations. The goal is to categorise the listening observations in meaningful ways while keeping the number of attributes and fuzzy feature sets to a humanly manageable number. This enables sufficient distinction among the range of descriptions of the sounds that occur in the music. The issues are balancing efficiency against detail while maintaining transparency with ordinal³ rankings and user friendly term sets while keeping the attributes independent.

¹ ‘Fuzzified’ is a term used in the fuzzy logic literature to denote the result of the process of transducing observed data points into elements of fuzzy sets.

² The theoretical background and logical principles of fuzzy logic are explained in detail in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see pp. 453-462).

³ Ordinal is a mathematical term which refers to an ordered list of objects without precise arithmetic values. See the Quick Reference Guide to Terms for more detail.

The first step in converting the qualitative listening observations into fuzzified data is a systematic review of all the qualitative listening observations to determine appropriate fuzzy categories: attributes, and their related fuzzy feature sets. One of the advantages of using fuzzy logic principles is that experts and non-experts can provide useful information to build the system. Akbarzadeh-T and Meghdadi demonstrate that the analyst can assign the degree of importance to the particular information being summarised in a collection of fuzzy data objects (Akbarzadeh-T and Meghdadi, 2008:89). As Stowell, Robertson et al. explain, when the analyst assigns the level of importance of information, the analyst is not only permitted, but also required, to use free associative thinking and impressions about the qualities highlighted in user descriptions of their experience (Stowell, Robertson et al., 2009:963). However, as Akbarzadeh-T and Meghdadi also identify, determining which aspects of the experience to highlight also depends on the number of occurrences of particular qualities (Akbarzadeh-T and Meghdadi, 2008:90). The actual terminology and the range of variation in the listener's qualitative listening observations are both important factors in the selection of specific attributes for the final representation of the music under consideration.

A further consideration is the need to find an efficient coding taxonomy. As Huang, Nikravesh et al. observe, "The difficulty in obtaining an optimal classification model is to balance the complexity of the rule base and the classification accuracy" (Huang, Nikravesh et al., 2008:400). It is most efficient to expand the number of attributes and fuzzy feature sets only when significant variations in the character of the sounds increase. As Naghdy, Wang et al. demonstrate, using a fixed range of predetermined fuzzy feature sets potentially suffers from two drawbacks: either the range of features is too small, so that significant variations are overlooked, or the range of features is too high, which means that unnecessary work is required to evaluate each sound event against the entire range of features (Naghdy, Wang et al., 1996). However, the number of classification categories must not over-ride the goal of providing/maintaining details on the information within each qualitative listening observation. This means that as more pieces of music are analysed it may be necessary to develop more attributes to distinguish different music. However, the characteristics of each set of qualitative listening observations for a piece of music may require extending the number of fuzzy feature sets.

In summary, a range of factors influence the selection of attributes and features to cover the qualitative observations about the sounds of any piece of avant-garde music in the most comprehensive way. These factors are the overall number of qualitative observations of particular features, the subjective insights of the researcher, and the basic attributes of a physical sound object. The impact of these various factors results in similar but different sets of attributes and features for different pieces of music. Four basic properties of sound are highly relevant to compositional design and to *Fuzzy IDEAS* because of their generality and their independence. *Fuzzy IDEAS* starts with three basic technical attributes: Amplitude, Register and Time, as well as the informational quality of a ‘physical sound object’⁴, which is represented by the attribute of Reflective Events.

a. Sound as metaphor

As discussed in Chapter 1 (see pp. 30-33) music requires human conscious perception for its existence, while sound simply exists like air, water and light, as part of our environment, so that music is clearly more than just sound. However, sound itself is a good metaphor⁵ for a piece of music. Acousticians provide a technically well-defined multi-dimensional definition of a physical sound object, which explicitly includes the time dimension, which is helpful in thinking about music as an unfolding process.

Using sound as a metaphor for music is supported by Gabrielsson and Lindstrom (Gabrielsson and Lindstrom, 2010:392-393), who report that listeners consider tempo and loudness to be the most influential factors in ‘expression’ of emotion (although timbre - tone-colour – plays a secondary role). This research clearly suggests that the two basic auditory attributes of any physical sound object (amplitude and frequency⁶) are clear cut and important in listening responses that include emotional content and, I suggest for other ideas being communicated in the

⁴ I use the phrase “physical sound object” as an umbrella term that refers to any one sound that occurs in the real world. Even though a ‘physical sound object’ is intangible, it can be measured and identified in acoustician’s terms. The term ‘physical sound object’ distinguishes these real-world occurrences from sound events in music, which in this thesis, are regarded as the essential fuzzy building blocks for music and therefore for *Fuzzy IDEAS*.

⁵ Following Spitzer’s definition of ‘metaphor’, I also use this term to indicate a model which maps one mental domain onto another (Spitzer, 2004:15).

⁶ During any single physical sound object one or both of these attributes may vary over time which can produce sequences of pulses suggestive of tempo.

music⁷. Therefore, Amplitude and Register can be considered as the essential basic technical attributes of music, along with Time⁸, and Reflective Events⁹.

Time is the third independent dimension of a physical sound object. Interestingly, empirical researchers do not seem to consider the impact of time on listener response, which is also an important aspect of compositional design. Explicitly including time consciously transmits one of the significant qualities of music as an artform. As Moore discusses “...music is a temporal art, its proper study necessarily includes a method for capturing, representing, and interpreting information about successive moments in time” (Moore, 1990:3-4). In *Fuzzy IDEAS*, Time is the unifying element consistently applied to all sound events rather than Event Duration. Conventional score-based music is reliant on the concept of duration using different symbols to denote notes of different durations as a primary element of staff notation. However, the real-time duration of each note is also impacted by the interplay of other discrete attributes controlled by the composer such as Sound

⁷ Several other theoretical descriptions of sound have been proposed to assist in thinking about avant-garde music and designing compositional techniques. For example, Cadiz suggests that the acoustic properties of soundwaves include “...four characteristics. Namely frequency, amplitude, duration and [wave]form (which produces timbre)” (Cadiz, 2006a:72). He uses these attributes to compose algorithmic music using digital synthesizers (Cadiz, 2006a). However, according to Babbitt, the sonic qualities of any individual note event in conventional music has five attributes. He includes timbre, as well as pitch-class, register, amplitude, and duration (Babbitt, 1958). Both these definitions include timbre because it is self-evident that a sound does not exist without timbre of some sort. However, timbre is an instantiation of a physical sound object, produced by the intersection of the actual frequency, and actual amplitude and time, as specified by the acousticians. Without any one of these three attributes, a timbre would not exist.

Further, timbre has two different meanings in music theory. At the whole piece of music level, timbre refers to the choice of instrument for performance, so that trumpet and flute are different timbres, in this thesis called Sound Source, while at the level of individual sound events, timbre refers to those nuances in tone-colour that arise through the interplay of other independent attributes of sound events such as Amplitude, Register, and Event Duration, as well as the Sound Production Method and Sound Source. Further, each of these attributes, which affect nuances of tone-colour, is controlled independently by the composer. Therefore, timbre is a quality of sound controlled by the composer. As a result, I suggest that timbre is a complex by-product of the other attributes and compositional design, rather than an inherent property of a sound object.

⁸ However, Gabrielsson and Lindstrom also observe that the impact of other music-specific variables, such as tone-colour, harmony and interval-size, on the perception of emotion in music is less clear cut and ultimately more complex. The impact of music on listeners is complex because it depends on the interplay of individual music-specific features with the presence and level of any other features (Gabrielsson and Lindstrom, 2010:392-393). Because these music-specific features depend on decisions made by the composer about what to emphasise in any particular music, they are not regarded as basic attributes for *Fuzzy IDEAS*.

⁹ The choice of names I have given attributes and feature sets are discussed in the next section 5.1.b. Terminology (see pp.167-177).

Production Method, Tempo and Metre¹⁰. Using Time to define the onset, and on occasions, the continuation or conclusion of sound events provides a general term that is widely applicable to computer music and other types of avant-garde music which do not have well defined rhythmic, tempo, or durational values.

When fuzzifying the qualitative listening observations, the time point of each sound event is 'quantised' into time increments by rounding down the observed time to the nearest five seconds prior to the observed time in which the event occurs. This is done for ease of measuring elapsed time between sound events. This is assumed to have little impact on the analytical results because attributes and features relevant to each event are still shown synchronously, even though the time intervals between observed sound events are no longer detailed to the exact second but rather to the nearest quantised interval. Thus, the timeline is simply a sequence of quantised observed clock time points of significant events in the aural experience of this music. The timeline is the principal way to 'lookup' the relationship between specific aural events including those in which one of the features of the sound has changed, or because the sound of the music stays the same and it is the continuation that attracts attention. Time is the one continuously consistent dimension against which the occurrence of all the other attributes and features can be measured.

Although acousticians are only concerned with physical aspects of sound, any particular sound inherently signifies, i.e. 'expresses', to human ears any of a range of possible ideas. For instance, the sound of an ambulance may signify that help is at hand, or alternatively, the same sound may indicate an accident has occurred.

¹⁰ Nonetheless, if appropriate to the qualitative listening observations for particular music, *Fuzzy IDEAS* can contain an attribute which refers to the relative duration of sound events. I have used this particular attribute, termed as Event Duration, in at least one of the demonstration analyses (see, for example, Table *Women in Transit*: Technical Attributes and Feature Sets on p. 325.) In some music, it seems more appropriate to replace Event Duration by Tempo, in recognition that it is not the duration of single sound events which are featured, but rather the number of sounds occurring within a period of time. Logically, if there are more sounds in a time period then each one must be relatively short, however, what Tempo describes is the cumulative nature of a steady sequence of notes with identical durations over a fixed period of time (see for example Table .2.6 *Scharlachrote* Buchstaben: Technical Attributes and Feature Sets on p. 285). Similarly, it can be more appropriate to use Sound Production Method, because differences in playing techniques affect the duration of single events, but not their density in time. However, the Sound Production Method also impacts the timbral quality of the sound events, as is not the case with Tempo and Event Duration. Therefore it can be more appropriate to describe the Sound Production Method, although in some analyses it can be better to use both Event Duration and Sound Production Method (see for example Table *Durations II*: Technical Attributes and Feature Sets on p. 361).

Therefore, to a human listener, the final basic attribute of sound is the informational property of a physical sound object, which is incorporated in the individual personal response to hearing that sound.

'Reflective Events' document the spontaneous thoughts that arise in reaction to the sound, or absence, of specific events or groups of events as they occur in the music. These mental occurrences include the internal reflections, thoughts, images and moments of focused attention on the music, or any awareness that some aspects of some sounds are unusual in the overall context of this music as it unfolds.

Some Reflective Events record the attentional/thought dimension that occurs with active listening. These Reflective Events record subjective opinions and judgements about technical aspects of the music through self-interrogation of the listener's responses by "How may this behaviour be sensible? rather than labelling it right or wrong" (Langer, 2005:56). Other Reflective Events document points of interest in specific compositional devices that attract the listener's attention and suggest ideas. For instance, an unusual sound in the music may lead to questions about it at the moment it is being heard, whereas at other times in the music this particular sound may not be unusual and so does not provoke a Reflective Event. The information documented for Reflective Events can explicitly include emotional or other ideational content suggested by the music. Reflective Events can also include any other thoughts provoked by this music that refer to things outside of the music: not memories *per se* but how this part of the music alludes to other aural experiences, for instance, references to jazz bands and rock bands can be suggested by particular configurations of features in the music.

Reflective Events are a significant means of documenting the listener's influence on how the music makes sense. The attribute of Reflective Events is supported theoretically from several perspectives. Stowell, Robertson et al, observe that participant observations reveal "...the conceptual structures the participants bring to the situation" (Stowell, Robertson et al., 2009:960), which these researchers go on to describe as important in their user-evaluation of multi-media systems (Stowell, Robertson et al., 2009:960). Langer, a psychologist researching mindfulness and decision-making, observes that typical approaches to decision theory do not incorporate any reference or weighting for novelty or surprise because it is difficult

to capture the unknown in mathematical formalism, hence analysis is frequently confined to speaking of well-known and well-defined events and event types (Langer, 2005:223 note 10). Further, as Walser asserts “We seldom learn to be consciously analytical and articulate about the things that are most important to us, the things we take for granted, the things which seem natural [consequently] analysis is a relational activity which needs to be explicitly stated” (Walser, 2003:24). Reflective Events might include information regarding nuances of events and phrasing; unexpected events which are (or not) resolved; repetition and variation (in materials); some feature or attribute which gives the music momentum to that listener; or a feature or attribute that gives the music coherence¹¹ to that listener.

In conclusion, the time patterning of Reflective Events might indicate aspects of the impact of the music on the listener. Reflective Events are quite personal, and consequently quite variable, but their occurrence means that the listener has consciously responded to aural events in the music. Reflective Events are a significant aspect of the auto-ethnographic research process embodied in *Fuzzy IDEAS*¹². Most importantly, the recorded Reflective Events remain musically and cognitively meaningful. The noting of specific reflective thoughts, not only attentional states, but also regarding what is occurring in the music helps highlight those events which are significant in shaping the listener’s perceptions of the ideas in the music. Because Reflective Events document the individual listener’s responses to the qualities of individual sound events and their unfolding over time, Reflective Events are a significant aspect of making sense of any type of music.

A significant advantage of using sound as a metaphor for music is that the acousticians’ definition of a physical sound object specifies a set of independent attributes, which can be measured and identified separately. This makes the metaphor of sound useful when it comes to using fuzzy logic principles in analysing music. As discussed in Appendix F. Overview of Fuzzy Logic Theory and its

¹¹ ‘Coherence’ is yet another fuzzy word from musicology that refers to a mysterious process that cannot be articulated yet seems to be a glue that makes successive sound events stick together somehow in some way to form a whole piece of music.

¹² Should information about the experience of the music be collected from a variety of listeners, documenting Reflective Events enables comparison of whether and how particular qualitative listening observations have been classified as Reflective Events.

Commercial Applications (see pp. 453-462) fuzzy logic contains fuzzy set theory and the concept of mathematical operations necessary to work with fuzzy sets when combining fuzzified data to draw conclusions¹³. However further extensions of these logical operators to multiple attributes and feature sets using the algebraic methods developed by fuzzy logicians becomes impenetrably complex and difficult to interpret in musically meaningful terms. It is also difficult to intuitively follow the flow of information.

As an alternative to conventional fuzzy logic operators, I have followed through on the concept of sound as a metaphor for music, by specifying that attributes in the fuzzified data must be independent from each other, as this allows for straightforward summation of the fuzzified data values, which is both arithmetically and visually transparent¹⁴. The key is defining only attributes which are sufficiently independent of each other, to make simple accumulation a meaningful summary of each layer of visual representations¹⁵.

¹³ Because fuzzy set theory undermines one of the basic axioms of conventional algebraic logic, there have been a range of mathematical solutions for performing logical inferences on the information contained in fuzzy sets.

One method for drawing inferences from fuzzy sets within one attribute has become relatively commonplace. This inference method is similar to the standard inference method used to work with the information contained in conventional sets. In this inference method, analysts use the minimum values of the membership functions of two fuzzy sets to find the 'intersection' of two fuzzy sets. This 'intersection' or 'Minimum' operator locates those events simultaneously included in both the sets. Other typical logical operators include 'union', which returns any events which lie in either of the sets; and 'exclusion', which returns only those events which lie in one set but not the other.

It is possible to carry out similar logical inferences, when working with a small group of feature sets in only one or two attributes by visually representing each fuzzy set by the geometric shape best thought to represent the membership values for any possible element of that set. However, Cadiz and Kendall's geometric representations of interactions between the nine fuzzy sets of only two attributes (Cadiz and Kendall, 2006:344) suggests that it could quickly become too difficult to comprehend the outcome of applying fuzzy logic implication methods when working with many attributes with large numbers of feature sets.

¹⁴ This concept of simple arithmetic summation also arises from regarding a physical sound object as a useful metaphor to represent the attributes of music. Aside from the philosophical reasons discussed in Section 5.1.a.Sound as metaphor (see pp. 164-168), a significant reason for using sound as a metaphor for music is because of the independence of attributes inherent in the acoustician's description of a physical sound object. As demonstrated in Kostek's evaluation of audio software across five performance attributes, the commonplace fuzzy logic operators are not always needed to process fuzzified data (Kostek, 1999:166 and 176). Acousticians visually represent the waveform of each individual physical sound object as the summation of the wave forms of its constituent independent frequencies, each with their own varying amplitude and length. As Kostek has demonstrated, this way of conceptualising a physical sound object is a useful metaphor for representing the accumulated results of the subjective evaluation of audio quality (Kostek, 1999:149).

¹⁵ For example, if the membership values of sound events classified into each fuzzy feature set of Register at one time point are added together this will give the Register of the entire ensemble at that

Because I am aiming for simplicity and accessibility through use of visual inspection to analyse the fuzzified data, I use the same logical operators to maintain consistency of calculations across all hierarchical levels of the fuzzified data. Therefore, I have specified that constituent fuzzy feature sets must be amenable to addition as a means of summarising the fuzzified data at the attribute level. This replicates common language summations such as a flute duo is the simple arithmetic summing of two flutes, and a chamber ensemble is a summation of an array of musical instruments.

Although using sound as a metaphor for music provides basic attributes for the coding taxonomy, as Gabrielsson and Lindstrom identify, there has been little systematic research on how localised harmonic structures, texture and choice of sound source, affects listener's perception of emotional content (Gabrielsson and Lindstrom, 2010:389), let alone any other ideas that may be suggested by the music. From a composer's perspective, each one of these un-researched attributes is an important component of design. Gabrielsson and Lindstrom also conclude there is no empirical research into how specific harmonisation methods and use of different chord types, harmonic progressions, or implied harmony affect expression (Gabrielsson and Lindstrom, 2010:393). However, not only is there is no empirical research which includes texture¹⁶, but this attribute is also overlooked by Gabrielsson and Lindstrom. Compositionally, texture is such an integral aspect of

point in time. Similarly, adding the membership values of sound events across the fuzzy feature sets of Amplitude at one time point gives a total Amplitude value at each time point. If this calculation is done for every time point this produces an Amplitude envelope for the whole of the music. In any of these cases, adding more input listening observations does not necessarily mean that the total value doubles, but rather that the visual representation will take a different shape.

¹⁶ Texture describes the overall quality of the music with reference to the number and nature of distinct parts that can be aurally distinguished within a given time frame, perhaps the whole of the music, or perhaps only a phrase. For example, a texture of four parts each of which is a melody line is called 'polyphonic' in conventional music theoretic terminology ("Polyphony"). Further, a texture that consists of two distinct parts is also termed 'polyphonic' if both parts are melody lines, or termed 'homophonic' if one part is a melody and the other is in chords, whereas a texture is described as 'monophonic' when there is only one part because either the music is an unaccompanied single line of notes, or when every note is sounded simultaneously with other notes, i.e. each sound event is a chord played in rhythmic unison (Randel, 1978:506).

design that it is as important to listeners' responses¹⁷. Although empirical research¹⁸ disregards the impacts of particular harmonic sequences and designs, harmonic designs are the principal territory of traditional musicological analysis. Interestingly, each of the attributes overlooked by empirical researchers is significantly controlled by the composer, rather than by the performer.

My coding procedure allows all these overlooked compositional attributes to be included if relevant to a listener's experience of the music. The coding taxonomy allows for, in fact thrives on, additional attributes emerging during the process of coding the qualitative listening observations into fuzzy logic entities. The metaphor of music as a physical sound object only specifies the basic attributes to be automatically included as a beginning of an open-ended conversion procedure. Therefore, even though texture, sound source or harmonic style are not specified as basic attributes, if a listener observes any of these distinctive attributes, then these additional attributes can be included in the fuzzified data.

b. Terminology

This section explores my reasons for giving specific names, or labels, to particular individual attributes and feature sets. Natural language labels are a significant aspect of fuzzy logic, as using words for labels avoids the complications of defining qualitative differences with mathematical precision, or finding appropriate measurement scales on which to compare sound events that have distinctly different qualities. The words which name both attributes and fuzzy feature sets are collectively known as a 'term set' for the fuzzy logic identities in the coding taxonomy.

¹⁷ Perhaps it is not common knowledge, even though the information is available in music encyclopaedias, but in the late 16th century the Roman Catholic Church decreed changes in the style of music composed for singing Mass because by then the polyphonic texture had become so elaborate that the words were no longer comprehensible. Palestrina (1525-1594) is credited with writing so successfully in this new plain style that he was appointed to reform the plainsong of the Mass. His reforms remained the official version until the early 20th century, when the Vatican approved newly-researched scholarly versions of the original 9-10th century chants (Collins Encyclopedia of Music, "Palestrina, Giovanni Pierluigi", 1984:404). This history of one style of music points to the significance of texture in compositional design.

¹⁸ Parncutt (1999) has conducted some research into the impact of long chord sequences on listeners.

Because one aim of *Fuzzy IDEAS* is to provide a transparently meaningful analytical process, it is necessary to provide a useful intuitively correct and transparent way of describing music in general. The term set is designed to characterise individual pieces of music with sufficiently distinct aural qualities so that analysis of the fuzzified data is meaningful. For the analysis to be useful in making sense of the music it requires a means of describing the essential sonic materials of the piece; the relative weighting of materials; the nuances of those sonic materials; and the effect of the sound of the music on the listener.

Suitable natural language labels are the key to describing these qualities across all genres of music. This generalised term set, and thus *Fuzzy IDEAS*, is to be applied to music from both the audio and the acoustic domains. For example, the use of more general terms such as 'Register' which can adequately incorporate specific features like Pitch and Frequency. This is similar to Clarke's ecological approach to music analysis, discussed in Chapter 2, Section 2.2 (see pp. 73-75) which is designed to overcome the assumption that musical entities derived from notational and analytical practices in musicology are psychologically relevant entities for diverse listeners (Clarke, 2005:197). Even if musically trained listeners hear, relate to, and describe events in music on the basis of music theory, empirical research is still unable to identify that 'uneducated' listeners hear, respond to, and describe the sound of the music in theoretic entities. Hence we need broad terminology to be able to follow any listener's descriptors to some degree when coding their qualitative listening observations into fuzzified data.

An important aspect of fuzzy logic is that fuzzy feature sets can be labelled with words, rather than numbers or letters, so that the particular aspects of the data that each feature set represents remains relatively comprehensible. Thus, a term set for the fuzzy feature sets for Register could be labelled 'High', 'Upper Mid', 'Lower Mid', 'Low', and 'Deep'. The selection of the labels in the term set reflects the specific interests of the researcher, so that an alternative term set for researchers interested in the quality of sound in space instance could be: 'Shrill', 'Moderate', and 'Boomy'.

Although we have books full of music-specific terms, it is difficult to find an appropriate terminology from existing music theory, which covers the entire range of attributes that together but independently, form a piece of music. Music terms

include static features, such as $MM=60$, and those that change over time, such as *crescendo*. The complexity of characterising a piece of music means that many of these terms can be relevant when it comes to describing any piece of music. Most traditional music terms simultaneously encompass a range of attributes so they do not easily translate into useful and meaningful independent attributes. Existing music terminology is useful shorthand precisely because music is a multi-dimensional medium. Therefore, simply using existing music terminology to describe an aural event could result in interdependent categories. Additionally, some music terms are only relevant to analytical thinking, such as voice leading, harmonic rhythm, formal structures, pitch class sets, or tonal schemes. However, this type of analysis depends on training that is only relevant to traditional instrumental music. It becomes less relevant when generating set of descriptors for a cross-genre model of music.

Another issue is to find a generalised terminology to describe complexes of events similar to the way conventional music theoretic terms such as ‘scale’, ‘arpeggios’, ‘tone row’, or ‘rhythmic motif’ describe particular groups of events. However useful these music theoretic terms may be in some situations, they arise from acoustic music on conventional instruments. The nature of groups in music is potentially diverse, but the actual groupings of sounds that occur in any specific piece may be significant to the idea the composer is expressing through this music. Indeed, in drawing conclusions about a specific piece of music, it may be necessary to consider the particular features the composer chooses to group, and the reasons the grouping occurs. In group events, each individual constituent event is not necessarily aurally significant, but rather it is the relatedness of the constituent events which is significant in determining groupings. For example, the constituent events may occur simultaneously, as in a chord; or overlapping, as with an arpeggio, or have discrete separation, such as a rhythmic motif. This means that group events become a sound event in their own right. We need to find general terms for groups which means the terminology will work across all types of music, whether performed on conventional instruments or on computers and other electronic gear.

Finally, we need a terminology that is a more directly relevant to the descriptors applied to the sound of the music by a range of listeners. Lesaffre, De Voogdt et al conducted empirical research into the way a broad range of listeners described a set

of music excerpts. The results establish there is significant similarity between listeners' qualitative opinions about the music excerpts on various dimensions from the technical, to the cognitive and kinaesthetic, to aesthetic judgements about the music (Lesaffre, De Voogdt et al., 2008:706). Importantly, the team's research shows there are significant differences in the way listeners with varied backgrounds selected different terms to describe the same piece of music¹⁹. Their statistical analysis of survey responses of 79 listeners found the most significant difference between listeners' qualitative labels was related to their familiarity with the particular music, rather than music training or gender (Lesaffre, De Voogdt et al., 2008:703). Thus, using natural language labels within the fuzzification process is an important way of acknowledging that different listeners will bring different ways of verbally describing their perceptions and responses.

I have used an alternative name 'Register' for the basic attribute of sound called 'frequency' by acousticians, because Register exists in its own right as a descriptor of an attribute of music. The existing term 'Register' already incorporates notions of pitch and frequency, while not being as precise as these latter terms. Therefore, Register can be used to describe all types of music, whether pitched or unpitched, acoustic or computer music, whereas Frequency (cycles per second) technically only makes sense in sound synthesis, and Pitch only makes sense in tuned acoustic music²⁰. Some listeners through familiarity and training may be able to identify some precise frequencies of specific sounds, such as A above middle C is 440Hz. However, this would be an exception rather than a general rule for most sounds for many listeners. Most listeners are unlikely to have this facility so that technical instruments, such as oscilloscopes, are required to precisely identify frequency values in cycles per second. As the purpose of using fuzzy logic principles is to

¹⁹ The term sets used Lesaffre, De Voogt et al, include terms like 'rough/soft' that were pre-determined by the researchers and are much more ambiguous than those currently in use in *Fuzzy IDEAS*.

²⁰ Pitch and pitch-class are different, but closely related, concepts in technical vocabulary of music. Pitch describes the location of an actual sound in the frequency spectrum. In music notation, discrete sound events are conventionally displayed by a combination of pitch and duration. The division of the octave into scale points, useful for music notation, and specification of 'harmony', has led to the concept of pitch-class, which denotes the same relative scale point that occurs at double the frequency of the initial pitch. In music terms these notes an octave apart. Further, while it is a point of pride for many musicians that they can identify individual pitches, not every analyst will have this ability, however, should an individual analyst prefer to use Pitch instead of Register then the method remains flexibly open to this possibility.

overcome the need for detailed identification, using the inherent precision of frequency is not necessary for *Fuzzy IDEAS* to produce useful results.

Similarly, the term 'Amplitude' is used in *Fuzzy IDEAS* because Amplitude incorporates the degree of audibility, or loudness, that is inherent in the more conventional music term 'dynamics'. The term 'dynamic' is routinely used in music to reference the loudness factor which may be static for one sound event, such as *sfz* (explosively loud) or which may change over time such as *diminuendo* (gradually getting softer). The term 'dynamic' is also used in automated decision-making and computer software environments where iterative decisions on variables in one problem are being made at sequential points in time²¹. *Fuzzy IDEAS* references both worlds of computer logic and music. Consequently, it is confusing to use the term 'dynamic' in two such different contexts within this research. To use the term 'dynamic' simply for degrees of 'loudness' would be quite misleading. Using Amplitude instead of 'loudness' also builds on the metaphor between a physical sound object and music.

Fuzzy IDEAS also gives importance to those aspects of listening that are external to the music such as the listener's conscious awareness of aspects of their technical perception, as well as the listener's thinking about the listening experience, and the sound of the music. These factors are recorded in the cognitive attributes of Partially Indeterminate Events and Reflective Events. These predetermined cognitive attributes²², Partially Indeterminate Events and Reflective Events, capture the lived experience of music as fully as possible. Table 5.2 below sets out the

²¹ See for example, Richard Bellman's paper "Dynamic Programming" in *Science*, 153:1 July 1966, pp. 34-37, in which Bellman introduces this new terminology. Contemporary examples of use of this term include Dubois, D and Fortemps, P. (2003) "Selecting preferred solutions in the minimax approach to dynamic programming problems under flexible constraints" *European Journal of Operations Research*, 160:3, pp. 582-598, and Esogbue, A.O. (1999) "Computational Efficiency of Some Fuzzy Dynamic Programming" *Computers and Mathematics with Applications*, 37, pp. 47-51.

²² The sense in which I use the terms 'cognitive' and 'cognition' is quite broad. My use of these terms in this thesis is concerned with conscious awareness of the impact of the music on the generation of human ideas. Jehan's discussion of music cognition encapsulates the possibilities and uncertainties in listening very effectively. Although, as Jehan explains "the boundaries of music cognition are not very well defined and the term should be used with great caution", he also argues that there is more to music cognition than the audio signal alone, when he asserts that "Types of extra-musical influences include concepts of music, culture, and emotions" (Jehan, 2005:35). However, Jehan conceptualises music cognition as that interaction between music listening and music memory which involves learning and then recalling specific features of pieces of music in order to recognise genres and styles, composers and performers (Jehan, 2005:115). By contrast, the factor of 'conscious awareness' is the driver behind my concept of 'cognition'.

predetermined fuzzy feature sets of these two cognitive attributes. An illustrative example of coding information from a single qualitative listening observation into these predetermined feature sets of Partially Indeterminate Events and Reflective Events is provided in Table 5.2. Example Coding of one Sound Event (see p. 178).

Table 5.1. Feature Sets of Partially Indeterminate Events and Reflective Events

Attribute	Fuzzy Feature Sets
Partially Indeterminate Events	Notable Single Feature of Multi-Attribute Event Emergent Feature Time Point Uncertain Sound Source
Reflective Events	Attentional Focus Time Point External References Evoked Recall of Similar Materials (in this music) Associated with Partially Indeterminate Events Free Range Thoughts

An individual qualitative listening observation may contain one or more types of uncertainty about the sound of the music, in which case, the associated sound event may be classified in more than one feature set of the attribute named Partially Indeterminate Events. Each of these sources of uncertainty is available to and can be purposefully implemented and controlled by the composer.

The analyst codes these various types of uncertainty in the qualitative listening observations into the three fuzzy feature sets of Partially Indeterminate Events. Sound events that have clear boundaries in the time domain, and contain only clearly identifiable features cannot be classified as Partially Indeterminate Events, even if those sound events can be described as elements of two or more possible fuzzy feature sets within an attribute.

There are three fuzzy feature sets of Partially Indeterminate Events. The first feature set is ‘Notable Single feature of Multi-Attribute Event’, which should be used when the listener observes that particular sound is quite complex, however only one aspect is clearly described. For example, a very loud and dramatic attack is

attention-grabbing, but if there are other sounds at the same time then those other sounds may be heard but will not be clearly described in the qualitative listening observation.

‘Emergent Feature Time Point’ refers to the time point at which a single attribute of the music comes to conscious awareness, or the listener is aware that a particular sound is no longer part of the music. However, the onset or end times have not been consciously perceived before this rise to conscious awareness. For example, a sound event may begin so softly that the moment it becomes sound rather than silence is fuzzy, or perhaps its precise origin is masked by other louder events, or perhaps this particular sound comes to awareness only because it is continuous over time. While it then becomes possible to note the time point of the end of this sound, it is impossible without repeated listening, and perhaps not even then, to go back and discover when this event started. The event is aurally significant, i.e. it reached consciousness, precisely because of its continuous nature. The analyst should code any of these types of qualitative listening observations as Emergent Events, located at the quantised time point the sound comes to conscious awareness.

The third feature set in Partially Indeterminate Events is ‘Uncertain Sound Source’. This feature set is used to classify those qualitative listening observations that document the listener could not identify a specific sound source for these strange and unusual sounds.

Reflective Events are an intrinsic part of the process of listening, but are distinct from the sensory perceptions of the physical, technical features of sound events. Five fuzzy feature sets of Reflective Events are designed to capture the thoughts and cognitive experiences of listening. Reflective Events enable comparison of types of listening observations within this particular analysis, and also between analyses by different researchers.

The first feature set, ‘Attentional Focus Time Point’, occurs when something in the music immediately grabs attention. The second, ‘External References Evoked’, refers to hearing allusions to other music or real world sounds in the music under investigation. The third feature set is self-evidently named ‘Recall of Similar Material (in this music)’, while the fourth is ‘Associated with Partially Indeterminate

Events' related to the fuzziness of perception of uncertain boundaries of specific individual events. The fifth type of Reflective Event is 'Free Range Thoughts', which the analyst uses to classify any other idea, thought or memory that had been observed by the listener as being in their conscious awareness at that time point.

Partially Indeterminate Events can be distinguished from Reflective Events because Reflective Events document self-reflection and insights in relation to the music under observation, rather than pure identification issues. By contrast, Partially Indeterminate Events are documented when various types of uncertainty are present in the physical qualities of the sound, rather than a thought reaction to the sound as documented by a Reflective Event. Reflective Events and Partially Indeterminate Events may occur simultaneously, but it is also possible that one or the other type of event will occur independently of the other. Not all Partially Indeterminate Events are Reflective Events because the particularities of the sound do not necessarily prompt a conscious thought response to the occurrence of this technical aspect of the music.

Another unusual attribute to explicitly include in music analysis, but significant to the impact of music on the listener, is Silences²³. Silence events are points at which the listener noted a significant moment of silence in the stream of sound. Typically, in music theory, silences signify an important break in the music, perhaps between sections or movement, although some silences may simply be rests between events in a rhythmic motif. This ambiguity within music theory for origins of Silences also translates into the sound of the music. This means that Silence Events do not necessarily have the same character depending on the context in which they occur. Therefore, either Reflective or Partially Indeterminate Events can simultaneously occur with Silence events, as it can take time for the implications of Silences to emerge, while the occurrence of Silences can induce all sorts of ideas.

²³ Although approaching Silence as a stand-alone attribute may seem to reproduce/introduce superfluous information, it works logically on two levels. It is logically and practically true that if there is no sound, then there cannot be Register, nor Sound Production Method, let alone Amplitude. Mathematically, in searching for a technique that will work additively and is transparent and intuitively meaningful, enabling other sound-related attributes to reach a zero level at Silence time points ensures that Silence events do not complicate the summative contours (i.e. horizon line, or envelope) in the visual representations.

In summary, in *Fuzzy IDEAS*, those moments from the music captured during listening as qualitative listening observations, after fuzzification become ‘sound events’. ‘Sound events’ could be a single sound, note, a melodic motif, a bass line, a silence, or any other configuration that is observed during listening. Each sound event is classified into various fuzzy entities. First, into the basic attributes of a physical sound object: Amplitude, Register, Time and Reflective Events. Then additional attributes, such as Event Duration and/or Sound Type, are added as needed. An attribute can then be covered by as many individual fuzzy feature sets needed to describe the nature of this specific experience of the music.

The elements of each fuzzy feature set are those sound events which have this feature to some degree. Sometimes classification of a sound event into fuzzy feature sets may rely on the analyst’s assessment of the degree to which this sound event has this quality relative to some preconceived mental construct of the proto-typical feature held by the analyst²⁴. The membership value for that sound event in this feature set then represents the analyst’s subjective truth value for its degree of ‘fitness’ in belonging to that feature set²⁵.

To aid in conceptualising sound and cognitive events and their representation over time, it may be useful to examine Figure 5.2 below. Figure 5.2 is a visual representation of my own experience of listening to *Scharlarchrote Buchstaben* (Heller, 1984). This chart shows the fuzzified data attribute level as this gives the single most complete overview of the technical and cognitive aspects of my experience of listening to this music²⁶. By contrast, the fuzzified data at the feature

²⁴ An important aspect of the coding taxonomy is that it can be “...applied in a wide variety of cases to probe the participants’ cognitive constructs produced during the experiment” (Stowell, Robertson et al., 2009:974). This can be done through “a principled approach which extracts a structured picture of the described world from a relatively small amount of interview data” (Stowell, Robertson et al., 2009:974). Cordon, Herrera et al. say that the first step of any fuzzy logic system is to create a “Knowledge Base”, which contains information given by the ‘expert’ human operator in words (as opposed to numerical data). (Cordon, Herrera et al., 1996:137-138). These researchers explicitly note that ‘expert’ knowledge is produced by the researcher gaining information from a person who works with materials and processes in some type of production system (Cordon, Herrera et al., 1996:139). If the operator knows how to make a process work, then they are considered sufficiently expert. Note there is no concern about the subjective and individual nature of this information.

²⁵ This does not presume the listener to be a musician. If the listener is not a trained musician, then they may describe the music with different ‘term sets’: the labels for attributes and features. They will still hold proto-typical mental constructs about the aural qualities they are describing.

²⁶ Figure 5.2 reproduces Figure A.1, from Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984) (see p. 290).

set level contains membership values. As a result, the feature sets give the most detailed visual representation of the listening experience. This level of detail requires multiple visual representations which are described in more detail below below below below below later in this chapter when introducing Stage 6. Constructing Visual Representations of the Fuzzified Data below below (see pp. 180-186), while set of actual examples at feature set level can be found in Appendix A. below in Figures A.2-A.7 (see pp. 289-291).

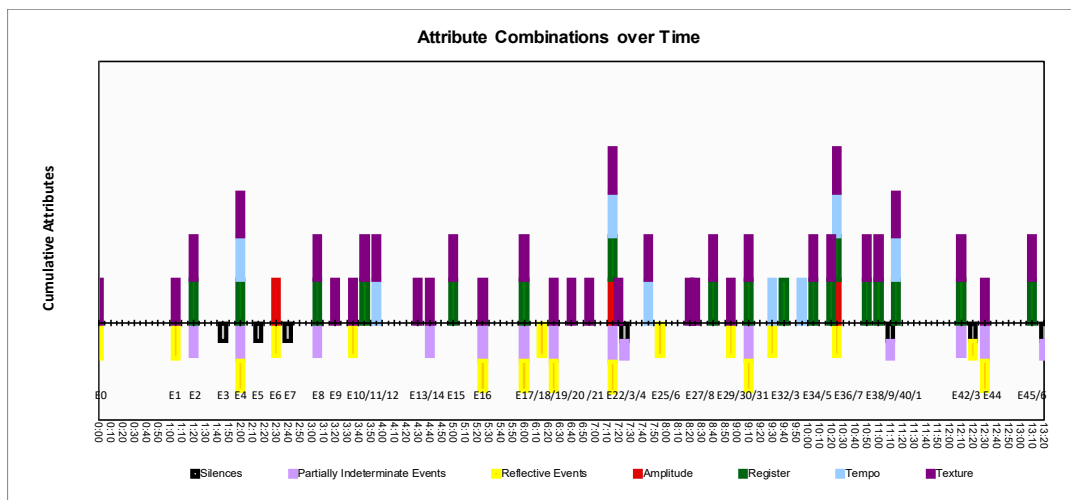


Figure 5.2. *Scharlachrote Buchstaben*: WS Attributes across the Time Domain

5.2 Fuzzy IDEAS: Stages 5-9 of the Method Explained

The method of information collection and analysis that is *Fuzzy IDEAS* was outlined above in Table 4.1. The Stages of *Fuzzy IDEAS* (see pp. 119-122). The following sections explain the systematic work flow an analyst can use to produce the series of visual representations of the music as experienced by mapping the fuzzified data for each sound event over the time domain.

Stage 5. Converting the Qualitative Listening Observations into Fuzzified Data

As previously explained in Section 5.1.a, my approach to converting the qualitative listening observations into fuzzified data builds on the metaphor of music as a sound object: that Amplitude, Register and Time are the three basic technical dimensions of a piece of music. Then, any other technical attributes and features of this music

important enough to attract the listener's attention, will emerge through the process of converting the qualitative listening observations into fuzzified data.

It is sometimes possible for the analyst, on the basis of 'insider knowledge' gained through music training regarding theoretical definitions of aspects of music to retrospectively infer other attributes or features. However, using only the information actually documented enables the pertinent dimensions of this specific experience of the music to emerge from the qualitative listening observations alone. Although more information would be available through repeated listening or studying the score, these activities remove the analysis outside of the context of this research: making sense of what the listener perceives on the first and possibly only hearing of a work, as takes place in a concert of new music.

The listener uses their own vocabulary such as "swirling group of sounds" to describe their perceptions of events in the music. As Efstathiou establishes, intuitively accurate models of complex situations occurs through ensuring user-friendly decision-making principles (Efstathiou, 1984:313). Stowell, Robertson et al., also conclude that drawing on a user's intuitive observations of their experience is a valid method for modelling and evaluating multi-media systems (Stowell, Robertson et al., 2009:964). However, instead of pitch and rhythm details, as taught in music theory and aural training, words are freely used to describe the nature of groups or series of events²⁷. *Fuzzy IDEAS* is similar to 'Ecological Music Perception'. Clarke's exposition of his approach explicitly states that any way of identifying and naming features of the music is perfectly acceptable. Therefore, the names of features could vary from a G#-A interval to naming the music as Beethoven *opus 132* (Clarke, 2005:158-159). Although some features might be quantitatively measurable, other features may only be described qualitatively in words. These feature descriptions may be added, deleted, or modified to more accurately reflect the analyst's intuitive appraisals of the qualitative listening observations. For example, Table A.2. in Appendix A (see p. 287) shows the technical attributes and fuzzy feature sets selected to classify my qualitative listening observations for *Scharlachrote Buchstaben*.

²⁷ Indeed, these grouping descriptions are an extra application of fuzzy logic principles.

The resulting hierarchy of fuzzified data describes a classification system for each qualitative listening observation at different levels of detail. The fuzzy categories for the technical details in the listening observations organised into attributes and then feature sets are designed to cover the sounds of this music in the most comprehensive way²⁸. Figure 5.1. Classification of Qualitative Listening Observations into Fuzzy Logic Entities (see p. 157 above) shows the process of converting qualitative listening observations into fuzzified data.

Table 5.2 below shows how the coding taxonomy can convert a single qualitative listening observation into relevant attributes and feature sets. The example qualitative listening observation has been taken from Table A.1. *Scharlachrote Buchstaben*: List of Cognitive Events (see p. 283). “5’25” - I have become aware of an unusual event where many different notes are being played nearly simultaneously, rapidly moving from one to another texture in a motion which did not sound random or chaotic, but rather as a swirling directed mass of sound.”

Table 5.2. Example Coding of one Sound Event

Qualitative Listening Observation	Sound Event	Attributes	General Description	Feature Sets	Membership Value
	E16	Time	Crisp time point	5’25”	N/A
		Amplitude	How loud is this sound event?		0

²⁸ Since music is multi-dimensional, even though the qualitative listening observations only contain those aspects of the sound of the music which stood out in some way to the listener and which could be documented, each listening observation also has the potential to be multi-dimensional, simultaneously containing different aspects of sound. As Huang, Nikravesh et al., conclude “The major advantage of using fuzzy rules for classification...is to maintain transparency as well as a high accuracy rate” (Huang, Nikravesh et al., 2008:400). Consequently, each sound event may be classified as an element of one or more defined fuzzy feature sets across one or more attributes. For example, a specific sound event could be documented as High-pitched and Loud, so would thus be classified in two attributes: Register and Amplitude. For example this sound event could be assigned to two feature sets within the attribute of Register: ‘Upper’ with a membership value of 0.4; and ‘Upper-Mid’ with a membership value of 0.8, which reflects the analyst’s evaluation that this sound event is more in the middle range than in the upper range, yet it does still contain some upper-register characteristics. It has also been evaluated as not having any membership in the fuzzy feature sets of ‘Lower Mid’, ‘Low’, and ‘Deep’, so that the membership values (or ‘degree of membership’) of those elemental sets is zero. Similarly, this sound event could be assigned to several fuzzy feature sets in Amplitude with varying degrees of membership. This multiple representation of a sound event captures the complexity of that individual sound event in some detail.

Qualitative Listening Observation	Sound Event	Attributes	General Description	Feature Sets	Membership Value
		Register	What pitch or frequency range is this sound event?		0
moving from one to another texture		Texture	Number and type of independent 'voices', i.e., strands of sound occurring simultaneously	Repeating Sounds	0.5
swirling groups of sounds occurring nearly simultaneously		Texture	Number and type of independent 'voices', i.e., strands of sound occurring simultaneously	Polyphony	0.5
from one to another texture		Reflective Event	Thoughts about the sound of the music which arise to conscious awareness at this time point	Recall of Similar Material in this music	0.5
rapidly moving from one to another		Reflective Event	Thoughts about the sound of the music which arise to conscious awareness at this time point	Associated with Partially Indeterminate Events	1
Swirling sounds, but not random or chaotic		Reflective Event	Thoughts about the sound of the music which arise to conscious awareness at this time point	Free Range Thoughts	0.5

Qualitative Listening Observation	Sound Event	Attributes	General Description	Feature Sets	Membership Value
I have become aware that so many different notes are being played		Partially Indeterminate Events	Is there something about this sound that has made it difficult to identify in some way?	Emergent Feature Time Point	1

Stage 6. Constructing Visual Representations of the Fuzzified Data

The purpose of this stage is to report the fuzzified data in a visual format directly representing various aspects of this personal experience of the music. The visual representations are constructed from the fuzzified data for each sound event at both attribute and feature set levels. The fuzzification of the listening experience produced N sound events over the duration of the music measured in minutes and seconds. In order to visually map the sound events across the time dimension, the range of time intervals between sound events is evaluated to find the smallest time interval between events as the base line for the time dimension. The quantisation interval selected for transferring the fuzzified data into the visual representations is based on the smallest time interval between time points. This is simply to make the visual representations small enough to fit on A4 size paper.

The visual representations are deliberately constrained to a form that allows meaningful and accessible visual and arithmetically logical operations. The purpose of these restrictions is to ensure that conclusions drawn, as well as the process of reaching those conclusions, will be relatively comprehensible to non-mathematicians. Because of the self-imposed constraint of independent attributes, there is no need to use fuzzy logic operators to manipulate the fuzzified data.

Because an important aspect of *Fuzzy IDEAS* is the explicit representation of aspects of the listening experience in an easily interpretable form, in varying degrees of detail - from the general to the particular, the primary goal is a direct representation of the multi-dimensional nature of music as it occurred to that listener over time in a manner that permits ease of visual analysis. The qualitative listening observations

recorded for specific music significantly affect the plotting of these visual representations through the results of the intermediate step of converting the qualitative listening observations into fuzzified data. The purpose is to provide a visual representation, which is meaningful and transparent, and can be analysed with little computational effort to provide evidence for how the music makes sense.

Visual representations can be a straightforward way of delivering complex information, if the mapping process is systematic and consistent. Here, the visual representations are designed to enable abductive conclusions about possible ideas in the music in a systematic way based on visual analysis of the fuzzified data. I have constrained the mapping process to allow easily performed and transparently comprehensible analytical operations on the information contained within the visual representations. My self-imposed constraints include maintaining consistency in colour schemes between attributes and associated fuzzy feature sets; ordinal rankings of fuzzy feature sets within attributes; inclusion of membership values and Multi-featured events where relevant; and ensuring that time intervals between sound events are mapped consistently to the time scales in the visual representations.

Sometimes an event is difficult to classify as it has qualities that permit its classification to some degree in one or more feature sets. For instance, the boundaries between the two feature sets of Texture - Duet or Homophony - are not clear cut. Some events have been simultaneously classified in both sets with varying degrees of membership, represented by different heights to show the different membership values in each feature set²⁹. By including this level of detail it is possible to see the relative values that individual sound events have in each feature

²⁹ Typically, degrees of membership are given values between 0 and 1, so if a sound event is thought to completely match the characteristics which define a feature set, then its membership value would be 1. If the sound event does not seem to match the characteristics of a specific feature set to any degree, then its membership value for that feature set is zero. The membership values across all fuzzy feature sets to which the sound event is thought to belong, are not constrained to sum to 1, but can add to any total (Roberts, Dowling et al., 1997:21-23). Theoretically, each fuzzy feature set contains all sound events with some degree of truth, including all zero values. However, as discussed in Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications (see p. 458), fuzzy logic users and conventional set theorists alike, reduce clutter and unnecessary calculations by omitting any elements in specific sets with membership value of zero. Therefore, typically in practice, if a sound event does not seem to fit a specific feature set at all, so its membership value in that feature set is therefore zero, then the sound event is not recorded as being part of that fuzzy feature set.

set³⁰. What is important in this Stage of *Fuzzy IDEAS* is that the event is Multi-featured, i.e. a member of more than one fuzzy feature set within the attribute. This is denoted on the charts by an event with an arrow at its base. At a higher resolution than possible when fitting the entire chart onto one computer screen, it becomes visually apparent that both sets have been included on the chart at that time point.

Time is a significant aspect of music as it is conceived and experienced. Placing the time scale on the horizontal axis provides the most immediate correlation between the visual and the passing of time during real-time listening³¹. Schubert, whose research interests include the measurement of emotional responses to music over time, observes that one of the major challenges of time series data is how to display it most meaningfully (Schubert, 2010:229-230). Schubert also suggests that placing time on the X axis, and the emotional response scale in the Y axis, is immediately informative. Further, he suggests that if investigating more than one data dimension then aligning the time scales so they can be visually compared is also immediately useful (Schubert, 2010:229-230)³². Schubert's assertions are intuitively accurate, hence, in the visual representations generated for *Fuzzy IDEAS*, time is on the horizontal scale, and information about attributes and feature sets is included in the vertical dimension. This realistic mapping ensures that time is a constant explicit dimension in the visual representations across each attribute and feature set.

The primary difference between Schubert's mapping and *Fuzzy IDEAS* is that the qualitative listening observations are not continuously recorded for every second of the music, and that the increments in time on the horizontal X axis of the visual representations in *Fuzzy IDEAS* are based on the smallest interval between

³⁰ Membership values also have potential future uses in two different ways. Firstly, when an analysis of specific music is used as a model for composition of new music based on the reconstitution of identical events at particular time points based on their categorisation into fuzzy feature sets. Secondly, *Fuzzy IDEAS* may be used on a large sample of listeners to establish generalities about aspects of the method, or commonalities of responses to the same music stimuli. In these instances, membership values are important component that enables the use of fuzzy logic operators to analyse these masses of data.

³¹ Turning the qualitative listening observations into fuzzified data and mapping them across the time domain allows for the possibility that the listener is not consciously aware of the temporal design being exposed by their qualitative listening observations as time unfolds. Mapping all fuzzified data across the time domain also allows for the possibility that the composer's temporal design can be based on one, multiple, or all qualities of the sound of the music.

³² It is difficult to find a visual example of Schubert's mapping. However, a snapshot of his mapping of one psychological response - arousal (a psychological descriptor of the strength of listening response) over time shows a single continuous line against a time scale marked in three second increments (Schubert, 2010:236).

quantised sound events. Because one goal of the visual representations is assessment of the overall temporal design in terms of the simultaneous occurrence of particular attributes and features, this compressing of time does not significantly affect the results.

Visual analysis is enhanced by a system of colour coding³³ that shows the relationship between specific features and attributes. Systematic colour coding assists in transparency of information contained in the visual representations within a piece of music and between pieces of music. This provides for ease of visual analysis because the information on each sound event will be presented in a consistent format, hence visual searches will more quickly locate similarity or differences. Consequently, each attribute is consistently one distinctive colour, for instance **Register** is always **dark green**, as shown in Table 5.3 below.

Table 5.3. Colour Scheme for Visual Representation of Attributes

Silence Events	Black
Reflective Events	Yellow
Partially Indeterminate Events	Lavender
Amplitude	Red
Register	Dark Green
Event Duration or Tempo	Pale Blue
Texture	Plum
Sound Production Method	Pink
Sound Source or Sound Type	Dark Blue

One consideration for choosing diverse colours for each attribute is that these colour choices are distinct enough to be recognisable when reproduced on most 21st century digital equipment. However, even with 21st century technology allowing colour in various media, different computer monitors and printers render colours outside of the black-white spectrum into slightly different shades.

³³ Personal associations of particular attributes with particular colours may be different for other listeners, but the important point is to provide consistency across the visual display for different pieces of music.

Another aim in colour choice is for consistency in the way the colour of each attribute relates to the ordinal³⁴ rankings of that attribute's feature sets. Similar to the colour coding for attributes, the fuzzy feature sets associated with each attribute are each represented by graduations of the main attribute colour³⁵. For example, each fuzzy feature set of **Register** is a different **shade of green**.

The series of colour shadings prescribed by the analyst for each fuzzy feature set is maintained across pieces of music as closely as possible. The aim is to provide a consistent visually recognisable mapping of fuzzified data at feature set level for different pieces of music. Using the same gradations and colour choices makes it easier to see the relative ranges of values covered by each of the fuzzy feature sets for that experience of listening to that music. For example, Figure 5.3, below shows the colour coding of six feature sets in Register, ordered from lightest shade to darkest shade to show the progression from Very High to Bass Register.

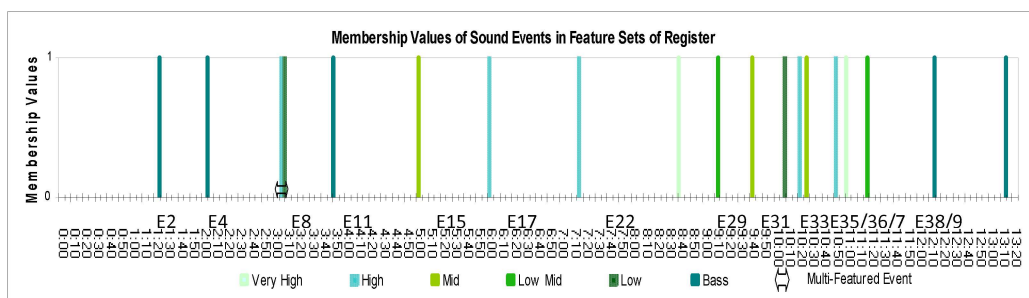


Figure 5.3. Colour Coding of Six Feature Sets in Register

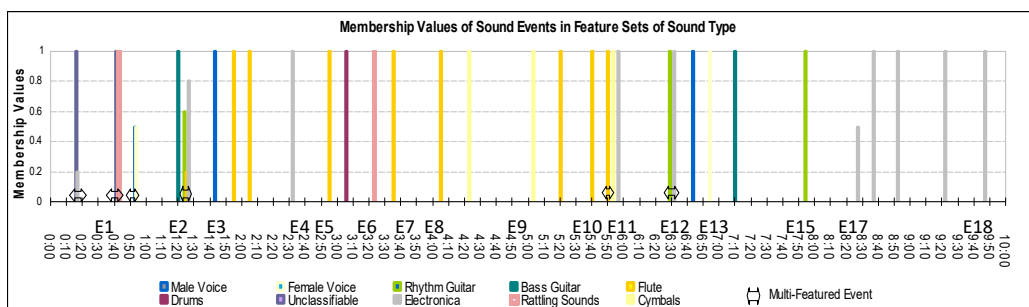


Figure 5.4. Colour Coding of Ten Feature Sets in Sound Type

³⁴ Ordinal ranking is a mathematical term used to describe the process of putting objects into a line in the order of highest to lowest in value, without having to specify the exact numerical value of each element. For example, it is possible to arrange a group of sound events from softest to loudest, without knowing the precise decibel value of each sound event.

³⁵ In cases where there are many fuzzy feature sets, there may be differences in density of the infill colour or the outline, determined by relative placement in the ordinal ranking of fuzzy feature sets.

While the goal is to find different colour gradations for the feature sets of each attribute, there may be some overlaps between the colours of feature sets in two attributes. Where there are many fuzzy feature sets this overlap occurs to ensure that differences between features within each attribute are easily visible. In these instances, the colour scheme for each ordinal scale is calibrated for its own utility in exhibiting the fuzzified data for that attribute, and secondarily calibrated in relation to the fuzzy feature sets of the other attributes for that piece of music. For example, Figure 5.4 above, the fuzzified data for Sound Type resulted in ten feature sets, so some of the shades of green used for feature sets of Register have had to be duplicated to cover this extremely large range of feature sets. Even within these limitations, colour coding of feature sets still show the relative differences between sound events over time in a multi-dimensional way.

As will be described in detail in Stage 7 and Stage 8, various aspects of the visual representations are subjected to further analysis through creating analytical charts, including the Frequency of Attribute Combinations and the Frequency of Transition Pairs. Because Attribute Combinations and Transition Pairs can occur in so many different variations, the identifying colour code for each attribute is maintained, then combined in various patterns with the colours for other attributes to assist with visual consistency in the representation of the fuzzified data within one analysis, as well as between examples of applying *Fuzzy IDEAS* to different music.

There are also visual aids to the detailed information held within each sound event. The ability to classify doubtful events in two or more sets is a significant feature of *Fuzzy IDEAS*, instead of having to eliminate the ambiguity of the event by deciding that only one feature is correct. The different membership values for a sound event in each fuzzy feature set is represented by differing heights of each feature set at that time point. An visual example of varying membership values is shown in Figure 5.5 below. The height is set at the level that reflects the membership value or the degree of certainty about its classification within this feature set³⁶.

³⁶ This still holds true for sound events where more than one feature is clearly observed so there is no uncertainty. For instance, it is possible for a sound event to include High Register and Bass Register simultaneously. As both features are certain, this sound event has a membership value of 1 in both fuzzy feature sets.

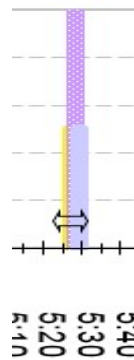


Figure 5.5. Visual Representation of Multi-featured Sound Event

In the text of the example qualitative listening observation on page 178 above, the listener identified several qualities for this sound event. The uncertainty contained in the description resulted in categorising this sound event into three feature sets of Reflective Events, perhaps with different membership values representing the degree to which the uncertainty affects the classification. This ambiguity is denoted on the visual representations with an arrow at its base as shown in Figure 5.5 above. Some other sound events are also denoted on the visual representations by a small double-headed arrow, particularly those sound events that clearly contain two or more qualities simultaneously, so those sound events need to be simultaneously categorised in several fuzzy feature sets of the same attribute. Both features are clear, there is no uncertainty, it is the inclusivity of the event which brings this about³⁷. As both the features are certain, they each have a membership value of 1. The value of 1 denotes that this event completely and simultaneously satisfies the criteria for both fuzzy feature sets. The same double-headed arrow mark both types of Multi-featured Events.

Stage 7. Analysing the Frequency of Fuzzy Entities in the Visual Representations

This stage draws out those attributes and features highlighted in the fuzzified data of this single experience of the music. Frequency distributions indicate the relative

³⁷ For instance, it is possible for a sound event to include both High Register and Bass Register simultaneously. An example can be found in Appendix A *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984) on page 289 where E8 at 3'05" is represented by two bars each with a height of 1, tied together by a double-headed arrow, denoting that this sound event simultaneously contains two differing Registers.

importance of attributes and features in describing this experience of the music. The relative occurrence of particular attributes and features implies that these particular qualities have been emphasised by the composer³⁸. The number of attributes and feature sets and their relative frequency also measures the amount of variation between individual sound events³⁹.

The frequency distributions of individual attributes include Silence events, Reflective Events, and Partially Indeterminate Events, while additional histograms show the frequency distributions of their associated fuzzy feature sets. An example is provided below⁴⁰.

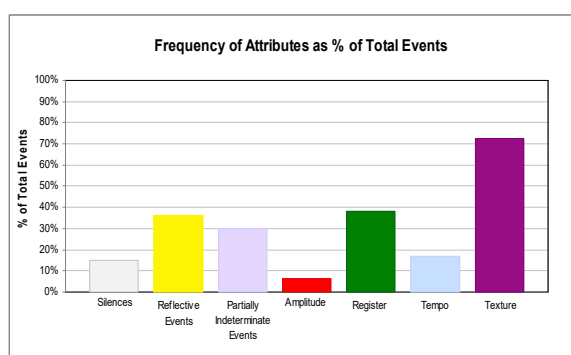


Figure 5.6. Example Analysis Chart for Frequency of Attributes

Attribute Combinations and Transition Pairs are both also included in frequency analysis. The analytical chart, Frequency of Attribute Combinations (see for example, Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller,

³⁸ Although it is important to recognise that the most aurally significant events may not just be those events that are repeated, but rather those sound events that are distinctively individual, the 'mode' is a useful descriptive statistic for *Fuzzy IDEAS*, as the mode shows the most common attributes and features in each experience of each piece of music. Other commonly used descriptive statistics include the 'average' or 'mean' calculated by mathematical formula which requires adding all relevant observations together, and hence blurring their individual identities; while the 'median' requires ranking all observations in order of relative degree, rather than across the time domain.

³⁹ The relative frequencies of both attributes and features are calculated as a proportion of the total number of documented events for that piece of music, so that the proportions are directly comparable between every piece of music. Of course, if there are fewer total observations for a piece of music, each individual observation assumes more importance in this type of calculation. Yet, this statistical artefact replicates the importance of each one of the small number of observations in producing the overall idea of the music. The alternative is to calculate features only as a proportion of events documented within the relevant attribute. This introduces more individuality into the percentages preventing transparently meaningful comparison of observed features from one piece of music to another.

⁴⁰ A complete set of analytical charts presenting frequency of attributes and feature sets can be found in Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984) (see pp. 292-294).

1984), p.295) reproduced in Figure 5.7 below shows the most and least common combinations of attributes, as well as the similarity between all sound events at the attribute level.

Frequency of Attribute Combinations provides information on the amount of variation between individual sound events, as well as those combinations of technical attributes that stimulated Partially Indeterminate Events and/or Reflective Events. Because this analytical chart provides a visual summary of the similarity in the listening observations, the data bars in the analytical chart are ordered not only in terms of decreasing frequency of technical attributes, but data points that represent the same technical attributes, but with different cognitive attributes, are also grouped.

Attribute Combinations which only consist of technical attributes always precede those with the same technical attribute combinations, but which also include Partially Indeterminate Events. The third ordinal ranking is to juxtapose those combinations for which the technical attributes are identical and include Reflective Events as well as Partially Indeterminate Events, while those Attribute Combinations that include Reflective Events but not Partially Indeterminate Events are placed last in the ordering for each group⁴¹.

⁴¹ Because Attribute Combinations can occur in so many different variations, there are colour codes to help find consistency among these particular analytical charts for different music. In this analytical chart those Attribute Combinations containing Partially Indeterminate Events are visually identifiable as they are always denoted by purple borders. Those combinations that include both Partially Indeterminate Events and Reflective Events have bi-coloured borders, while those Attribute Combinations that include Reflective Events but not Partially Indeterminate Events are denoted by yellow borders.

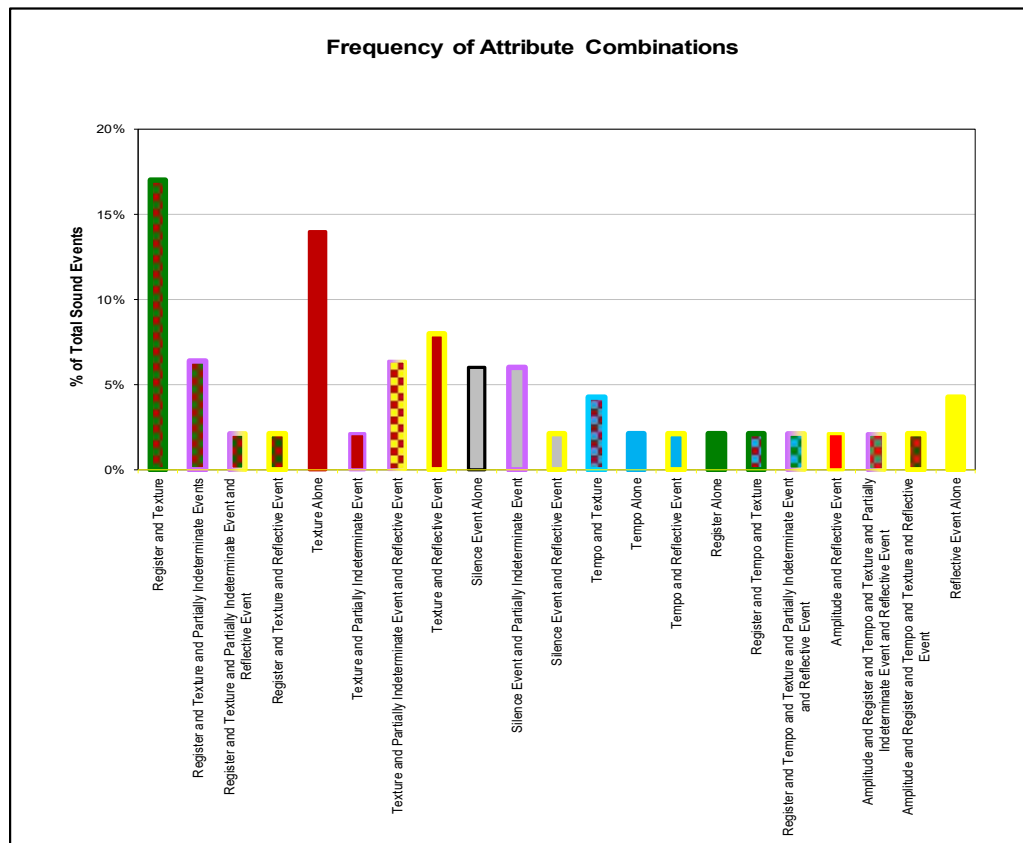


Figure 5.7. Example Frequency Analysis Chart for Attribute Combinations

Analysing the Frequency of Transition Pairs, is an additional way of investigating compositional design⁴². Analysing the qualitative relationships between individual sound events summarises how particular attributes of each sound event morphs into the qualities of the next sound event. As Serra, Corral et al., state that the most useful way of identifying important aspects of transitions between sound events is by counting the number of times the same features of each two adjacent events are repeated (frequency of relationship), and by counting the overall number of variations in Transition Pairs (Serra, Corral et al., 2012 ,Supplementary Information:7-8). These researchers and Cope are using automated analytical systems which enables them to count transitions between every note in the music.

⁴² As Cope explains “The topology of these networks [between sound events] and common metrics extracted from them can provide us with valuable clues about the evolution of [a] musical discourse” (Cope, 2005:329). Similarly, Serra, Corral et al., observe that “One way to account for syntax is to look...analogously to language-based analyses [at the] transition networks formed by codeword successions...” (Serra, Corral et al., 2012:3). Serra, Corral et al., use the term ‘codeword’ to denote the symbols they use to denote the pitch, timbral, and loudness qualities of chords in the music under analysis (Serra, Corral et al., 2012:4).

In comparison, it might seem that an unpredictable amount of time elapsing between one qualitative listening observation and the next may impact on the value of transition pairs in *Fuzzy IDEAS*. However, the same argument still applies. Repetitive occurrences clearly suggest compositional emphasis on use of materials and the formal design. It might be expected that using qualitative listening observations may result in greater variation between Transition Pairs, because occurrence of the unusual is highlighted in human listening⁴³, whereas the unusual is less obvious in these machine-listening methods. Reflective Events are included in counting variations between Transition Pairs because occurrence of a Reflective Event is attributable to the technical attributes of the actual sound event and the sound events preceding it. An example summary analysis of Repeated Transition Pairs can be found in Table A.3. *Scharlachrote Buchstaben*: Repeated Transition Pairs at Attribute Level (see p. 296). Frequency of Transition Pairs is presented in text form because the comparison of each sound event with its immediate neighbours produces such a wide range of variations, it is difficult to sufficiently distinguish the nuances of each variation in visual format.

Stage 8. Analysing the Time Structure of the Visual Representations

A set of analytical charts explores the whole of the music over the time domain at attribute level. The goal is to detect patterns over time⁴⁴. It is self-evident that every piece of music will display some sort of temporal design, ranging from chaotically unpredictable to complete order and predestination. The time domain is the framework over which all the individual events are performed, while the temporal design itself informs how the individual events will be and are perceived. Some or all of this may have been consciously desired by the composer, while other parts may simply arise through the listener's perceptions of the music and the analyst's perceptions of the sound events themselves. However, given the premise that a composer's work is to express an idea through the medium of sound, then presumably the temporal design is one means by which they express their ideas.

⁴³ There is an inherent need in human information processing to simplify complex data streams such as music, while the initial collection of the qualitative listening observations and the fuzzification methods of *Fuzzy IDEAS* means that some attributes are omitted in the sound event descriptions.

⁴⁴ This analysis is similar to automated machine-listening analysis of digitised audio files, such as those conducted by Jehan (Jehan, 2005:37).

Visual analysis of the sound events in the time domain can quickly reveal the shape and nature of the music in a comprehensive way by analysing each individual time domain representation through simple observation of what is visually obvious, looking for unusual sound events as well as obvious replications of events or event combinations. Then the analysis continues by looking at how the patterns in each time domain representation interlock with the others. The complex nature of music contains the possibility that different aspects of the music have different structures designed to interact with each other in various ways, perhaps reinforcing each other, perhaps overlapping in a more complex temporal structure.

In *Fuzzy IDEAS*, the time domain analysis is performed through intensive segmentation of the visual representations in various ways. This can be useful for determining visually obvious structures within the perceived sound events, even if not consciously recalled during or after listening. Different ways of segmenting the time domain are studied separately because of the multi-dimensional nature of music. A complete set of examples can be found in Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984) (see pp. 298-306). It is also possible to note the timing of unusual events that don't recur in other places in the work. As Schubert notes "...the number of place markers and their location can provide interesting information in themselves" (Schubert, 2010:229). Visual analysis also enables the comparison of the time-pattern of events within each section of the music to see what similarities and differences exist between segments.

Firstly, the music is segmented by the timing of Silence Events (see for example Figure A.14. *Scharlachrote Buchstaben*: Segmentation using Silence Events as Break Points, on p. 300). Silences have been chosen as markers for the ends of sections because they always occur at the end of a piece of music, and usually occur between movements, although not always between phrases, or thematic sections. Perhaps, as Cope suggests, those patterns, which occur most often, are parts of major themes in the work being analysed, while rare patterns may be insignificant (Cope, 1996:101). This segmentation incorporates the synchronous attributes for each documented time point. Effectively this is a focus on the contour and types of sound events between each Silence Event, rather than the contour of complexity across the whole of the music.

Secondly, two analytical charts show the temporal design of event complexity on two different dimensions of both documented complexity and documented uncertainty. The contour of Attribute Complexity across the whole of the music is highlighted by the analytical chart Max-Min Technical Attributes across Time (see for example Figure A.15, on p. 302). This analytical chart highlight the time points at which the most complex and least complex combinations of technical attributes occur. The temporal distribution of Partially Indeterminate Events is charted separately (see for example Figure A.16, on p. 302). Partially Indeterminate Events are included because the indeterminacy, which automatically generates classification as a Partially Indeterminate Event, visually documents the inherent complexity in that sound event produced by the fuzziness in perception of some boundary of the event. Together these two charts show those time points of significant complexity, and indicate the degree of perceived repetition and variation in the technical aspects of event complexity.

Finally, the time points of the Most Common Attribute Combinations are examined for obvious replications of sound events with identical attribute combinations across the time domain. This analytical chart (see for example Figure A.17, on p. 304) includes all attributes, cognitive as well as technical attributes. For some listeners, cognitive events may be their primary response while listening to the music. This analytical chart allows that information to rise to the surface in these instances. Overall, this analytical chart provides information on whether and when specific sound events with identical materials are repeated at different times, which can imply repetition or variation as the music unfolds. This gives another insight into forms such as *rondo*, where the opening theme is repeated several times after interjected alternate sections.

Finally, Stage 8 of *Fuzzy IDEAS* includes an analytical chart that shows the Most Common Transition Pairs across the Time Domain (see for example Figure A.18. *Scharlachrote Buchstaben: Repeated Transition Pairs across Time*, p. 306). This analytical chart is a time domain mapping of the information in the Table of Repeated Transition Pairs⁴⁵ discussed in Stage 7. Analysing the Frequency of Fuzzy

⁴⁵ The information in this table requires analysis of how frequently any one specific Attribute Combination is followed by other specific Attribute Combinations through a stepwise adjacency

Entities in the Visual Representations (see pp.189-190 above). This analytical chart may give some insight into the internal design principles of the music in relation to formal design through the return of materials at particular time points⁴⁶.

Stage 9. An Abductive Interpretation: the Idea that Makes Sense of this Experience

The final stage of *Fuzzy IDEAS* is concerned with considering what this experience of the music might suggest about the idea that may have been the foundation on which this music was composed. Stage 9 uses all the information gathered while experiencing and analysing this listener's responses to this music. Other analysts may arrive at different interpretations. The conclusion drawn in this section is one possible way to make sense of this music. This stage addresses three main questions: What compositional idea is suggested by this analysis? What materials in the music produce or project this idea? How does the temporal design impact on perception of the ideas the composer is expressing?

This final analysis discusses the attributes and features most emphasised in this music, as well as those that seem the least significant, and how these insights influence the interpretation of this music, in order to explore what and how the analytical charts suggest about ideas in this music, explicitly taking into account:

- thoughts about how the music might make sense immediately after listening and the impact of Reflective Events while listening
- what the frequency distributions of attributes and features indicate about specific materials in the music which produce or project this idea
- the features of Silence events, Reflective Events and Partially Indeterminate Events in this music
- the amount and shape of uncertainty as indicated by the time domain patterns of attribute complexity and Partially Indeterminate Events
- visual analysis of fuzzy feature sets in the time domain
- frequency and time domain analysis of pair-wise adjacent Transition Pairs

comparison. (see for example Table A.3. *Scharlachrote Buchstaben*: Repeated Transition Pairs at Attribute Level (see p. 296)

⁴⁶ For example, in sonata form, there are several points of direct repetition of thematic materials and section endings.

- sectional segmentation by Silence events
- other possible segmentations of the time domain based on analysis of the most common attribute combinations and Transition Pairs

These final steps impact on conclusions regarding the temporal design of the work, and how the apparent temporal design is relevant to the composer expressing their ideas. As Jehan observes, the final stage of analysis collates information for an overview of the music for long term use (Jehan, 2005:37). This stage documents the process of making judgements about the music through asking “How may this behaviour be sensible? rather than labelling it right or wrong” (Langer, 2005:56). Stowell, Robertson et al., also demonstrate the importance of this approach for building functional interfaces between users and systems by allowing the model to emerge from intuitive information supplied by users (Stowell, Robertson et al., 2009:964). *Fuzzy IDEAS* includes the implications of the title as part of an individual listener’s observations about the music, to draw conclusions about a plausible meta-idea being expressed by the composer through this piece of music.

The analytical results are used to understand how specific technical aspects of the compositional design enables this music to make sense to this analyst. Berger argues that “A worthwhile objective is...starting from what this music itself is, rather than dwelling upon its deviation from what music was previously” (Berger, 1963). As Stowell, Robertson et al. explain, the most useful way of analysing listener observations includes using free associative thinking and impressions about the information collected (Stowell, Robertson et al., 2009:963). For instance, using open ended questions such as: What are the implications of the title for the composer’s ideas to be expressed through this piece of music? What aural features are projected in this music⁴⁷ and how might that suggest ideas with which the composer is concerned? What suggestions does the analytical information produce about the

⁴⁷ For example, music which might be described as peaceful and serene, which has risen to prominence precisely for this reason, such as Pachelbel’s *Canon*. However, my listening response is to find the music initially somewhat annoying, but then ultimately restful. Its major characteristics are thematic repetition, and that it sounds as if it is building up to finish, but then it does not end, instead continuing with repetition. The restful character of this music arises because there is calm regular movement among legato events, a regular pulse and most events are of the same duration. While there is clear phrasing and everything sounds unhurried at a regular tempo, there is little variation in register, which remains in the middle range of the instruments, there is no strain but great similarity in the delivery of each sound event.

ideas in this music? What occurs in the sound of the music, and the analysis, that gives rise to these suggestions? Other possible questions include: What in the music causes perception of the possible ideas? What does the listening experience suggest about the compositional process? Are there any audible processes?

Other questions will continue to arise as the analysis proceeds, until conclusions are drawn about how the piece of music makes sense. This conclusion is based on the initial abductive hypotheses immediately before and after listening, as well as insights revealed by visual inspection of the analytical charts, to facilitate evidence for an idea which makes sense of this music. I am not arguing that this idea is the correct interpretation or that the composer intended to communicate this specific idea. Rather this idea is only one possible way to make sense of the music. Other analysts may arrive at different interpretations.

Summation

My research investigates whether the practical application of fuzzy logic principles in the visual representation of the complexity of a personal listening experience is a useful and informative contribution to understanding how a piece of avant-garde music can make sense. This practical detailed application of fuzzy logic to music analysis is the substantial contribution of my thesis. This investigation occurs within my new method of listener-oriented music analysis designed as an abductive process for making sense of a piece of Western avant-garde music based on the complex information available from a single intangible personal experience of listening. The visual representations are designed to contribute to the “...discovery of a rational explanation for that judgment” (Darlhaus, 1983:3)⁴⁸. Visual representations are useful because they provide a compact format for presenting this complex information: technical observations and judgements about the music including the passing of time as the listening experience unfolds.

⁴⁸ Darlhaus emphasises that dislike of rational explanation for value judgements is a relic of the past that has no place in present day thought. He observes that this distaste for rational explanations of response is a social, rather than scientific attitude. Darlhaus asserts that applying aesthetic value judgements, as distinct from rational argument, was one of the assumptions embedded in aristocratic class privilege in the 17th and 18th centuries (Darlhaus, 1983:4). As discussed Chapter1 (see p. 30) I suggest that a stream of sounds that makes sense to a listener will be valued as music rather than ‘noise’. Thus, the way in which a listener makes sense of a stream of sounds also has implications for that listener’s judgements regarding its value.

Documenting the complexity of music is challenging. Cope suggests that the music score has been adopted as a visually intelligible representation of music as it is not too complicated (Cope, 2005:123). However, scores are only intelligible to those who can read music fluently, let alone the previously discussed problems surrounding the score as an adequate or useful representation of the lived experience of music. By comparison, computer engineers have found that mapping actual audio streams into other data formats has several benefits. Various researchers using automated listening techniques note that mapping and reformatting audio data can flexibly represent various aspects of the music, while remaining grounded in auditory perception. These researchers also report that data structures in symbolic form can be analysed quickly and effectively (Jehan, 2005:120; Arcos, Gaus et al., 2013)⁴⁹. The principle visual representation, which summarises the whole of the listening experience, is Attribute Combinations across the Time Domain. A set of visual representations shows how fuzzy features are distributed over time within each attribute. This provides a straightforward visual means to search for unusual features and also the location of obvious replications of identical features across the Time Domain.

The types of fuzzified data used for the visual representations arise from using the acoustic and associational properties of sound as the metaphor for music, which help maintain independence of attributes. They each represent aspects of a sound as an object that must by definition include Amplitude, Register, Time, and Reflective Events. However, to only describe all music in three basic domains derived from the acoustic properties of sound plus the additional attributes of Reflective Events, Partially Indeterminate Events and Silence Events, potentially leaves out many details that make individual works interesting to the composer and the analyst. Hence, the importance of introducing additional attributes if they seem to be relevant to a particular experience of music. *Fuzzy IDEAS* also incorporates an attribute labelled Partially Indeterminate Events, which contains a collection of technical/perceptual complexities that cannot be clearly captured elsewhere within the other discrete technical attributes. Some other sound events may also be complex, containing a range of features across a number of attributes, but each of

⁴⁹ Although this is not the main point of my thesis, the results of my research may shed some light on the validity of these remarks.

these individual features is quite clearly bounded and described by relevant fuzzy feature sets, or by specific points in the time domain. This ability to include both crisply defined as well as uncertain events is a strong feature of fuzzy logic.

In this chapter, I have set out the method for reporting the experience of the music in visual form, by first converting the qualitative listening observations into fuzzy logic formats of attributes and their constituent fuzzy feature sets. These fuzzified versions of the qualitative listening observations are then represented visually.

Because *Fuzzy IDEAS* is designed to be inclusive, transparent, systematic and transferable, the new method is demonstrated using my own experience of listening to four pieces of avant-garde art music. These practical worked demonstrations of *Fuzzy IDEAS* can be found in Appendices A-D (see pp. 279-437). A small evaluation study is outlined in Chapter 6, Section 6.2 Evaluating Fuzzy IDEAS as Analytical Method. I conducted this indicative evaluation to establish proof of concept that there is value in applying fuzzy logic principles as a means of using the technical aspects of music observed during the experience of listening to suggest ideas that inform that music⁵⁰. Chapter 6 contains a more detailed discussion of the design of *Fuzzy IDEAS* and the results it produces, as well as noting some unexpected practical benefits of using *Fuzzy IDEAS* for music interpretation.

⁵⁰ Because the purpose of this thesis is to explain the theoretical foundations of *Fuzzy IDEAS* the evaluation was not concerned with establishing the commonality of listeners' perception of any specific ideas projected by the music selected for the test.

Chapter 6. Discussion of Mechanics of *Fuzzy IDEAS*

One of the major tasks of my research has been to translate the concepts of fuzzy logic into something practical and workable in the music domain. Most fuzzy logic theory is explained in complex mathematical formalisms and proofs of concept, while the practical applications are to engineering technology such as running trains and cement factories. These applications are described in the literature as production problems, to increase productivity and profit. These applications imply that fuzzy logic is only good for production and management decision-making.

Making sense of the experience of any music, let alone avant-garde music, requires a large effort for little payoff. To paraphrase Córdón, Herrera et al, making sense of avant-garde music requires continually processing a long stream of “...perpetually novel events accompanied by large amounts of noisy or irrelevant data [with] implicitly or inexactly defined goals [exacerbated by the] sparse payoff or reinforcement [of appreciating the music]” (Córdón, Herrera et al., 1996:154). Córdón, Herrera et al, demonstrate that similarly complex problems such as economic systems, and games have been successfully modelled using various methods from artificial intelligence (Córdón, Herrera et al., 1996:154). Córdón, Herrera et al. assess fuzzy logic as particularly suitable for the task of classifying uncertain information from continuous input in a way which continuously improves results but does not need to revise existing classification of previous information in the light of this new perspective (Córdón, Herrera et al., 1996:160). Theoretically, then, fuzzy logic is a very useful method for making sense of avant-garde music.

Córdón, Herrera et al (1996) are Spanish computer scientists who write about knowledge representation in robotics and intelligent systems control, including using fuzzy logic to help computers learn about classifying objects and how to process those objects appropriately. They explain that human experience provides more direct knowledge about the system than any mathematical model, particularly in understanding systems with unknown attributes, or which are highly complex and non-linear. These researchers note that a human process operator is considered to be an ‘expert’ simply because an experienced operator can describe

the relationships existing in the procedure, even if they do not have precise numerical values for inputs and outputs (Cordón, Herrera et al., 1996:137). Any automated systems based on human experience are thus called ‘expert systems’.

The process of finding out the workings of a system being modelled aims to “simultaneously and cooperatively” discover linguistic information that describes important elements of the process, and the fuzzy rules that govern the process (Cordón, Herrera et al., 1996:150). As Elkan observes, expert systems require a large base of explicit knowledge in order to perform tasks that require complex reasoning with this information (Elkan, 1994:47). This requires a process of simplifying the set of rules while approximating the input-output behaviour for the real system (Cordón, Herrera et al., 1996:151). These researchers argue that the complex systems they are modelling require particular ways of learning about the system which can absorb and classify new information and devise new rules without disturbing what has already been acquired (Cordón, Herrera et al., 1996:154). They observe that these types of complex systems are found in environments such as economics or finance, or complex games such as chess. These environments “...exhibit some of the following characteristics: perpetually novel events accompanied by large amounts of noisy or irrelevant data; continual, often real-time, requirements for action; implicitly or inexactly defined goals; and sparse payoff or reinforcement obtainable only through long action sequences”. How well this description of complex environments defines the process of making sense of music.

Other researchers have applied fuzzy logic to aspects of music in a variety of ways. Predominantly, they followed the engineering model by applying fuzzy logic to control several predetermined variables in automated composition, performance or analysis of music. However, fuzzy logic is only applied within parts of those automated systems or only to one or more attributes of sound events. None is completely grounded in fuzzy logic, wholistically inclusive of all attributes, nor realistic about music as a lived aural experience, which is affected by every quality of the music, not only pitch as suggested by the focus of most music analysis¹.

¹ For example, Heister’s (Heister, 2012a) conceptual work that fuzzy logic can be applicable to music, remains at pitch cluster level. His ideas do not extend to the practical level of defining sets, establishing membership of those sets and making a clear-cut analysis, but rather demonstrates that the music

My research is an exploratory application of fuzzy logic to visually represent a single experience of human (as opposed to machine) listening as a means to explain (provide evidence for) how any piece of avant-garde music can make sense. Music analysis is concerned with understanding how the music being studied makes sense, so this question of making sense is not new. The significance of my work lies in transforming a unique intangible complex process of a lived personal experience of music into visual form in a way that synthesises 'affect' with technical details. This lets us see inside an intangible ethereal experience, to provide evidence for how the music has the impact that it does on that listener. This feeds into 21st century music analysis, compositional practice and pedagogy, and future technical developments, thereby eventually growing audiences for avant-garde music.

In this thesis I have explained the philosophical and theoretical basis for my method and the mechanics of its operation. This chapter discusses two major aspects of *Fuzzy IDEAS*. First, an evaluation of my application of fuzzy logic principles in relation to fuzzy logic theory. Second, a discussion of the implications of my evaluation of the practical utility of *Fuzzy IDEAS* for working with information about the same piece of music from a range of listeners, along with four complete worked examples which show the complete application of the method to four different pieces of music. The worked examples are included in Appendices A-D, while the documentary information regarding the evaluation, and the actual results from the evaluation are included in Appendix H and Appendix I.

In summary, evaluation shows that *Fuzzy IDEAS* has these positive benefits:

- the method of data collection has some ecological legitimacy because it uses a complete piece of music unknown to the participants before listening, played through once only. Thus, participants were faced with a situation similar to hearing and making sense of a concert-hall presentation of a new piece of avant-garde music with which they are unfamiliar
- the complete method allows a process of abductively making sense of music as new information comes to light: at any time while listening, immediately after listening, and after analysis of the visual representations

score is open to many possible interpretations, so it is not a definite document; that finding consistently bounded events in the score can be difficult; and that even when found, these events may not be heard in the music, leaving open the question of their actual significance.

- the method is systematic and repeatable across listeners and across different pieces of music

Moreover, evaluation of practical examples of applying *Fuzzy IDEAS* show some additional benefits of the data collection method which encourages active listening:

- attention to the music is improved
- the experience of avant-garde music is enhanced

Finally, compared to the time it takes to collect the qualitative listening observations, a large amount of time is required to manually construct the visual representations. However, the visual representations have these advantages:

- the process of creating the visual representations has strong potential for automation
- the visual representations add value to the analysis through providing accessible documentary evidence of technical aspects of the music which contribute to the music making sense
- the visual representations show a lot of detail about a single experience of the music
- the visual representations capture subjective and technical responses in one place
- the visual representations allow us to investigate perceived structure, even without conscious awareness by the listener
- the content of visual representations varies with each listener, but each still produces enough information to make sense of the music, so the process has positive benefits across listeners
- the content of the visual representations varies across pieces of avant-garde music, but each still produces enough information to make sense of the music so the process has positive benefits across different music

Together, this evaluation shows that using fuzzy logic to represent an individual experience of listening to music has considerable benefit.

6.1 Application of Fuzzy Logic Theory in *Fuzzy IDEAS*

The purpose of *Fuzzy IDEAS* is to enable us to explore the subjectivity of each listening experience in detail on its own terms, not in comparable terms between listeners or between pieces of music. As will be discussed in Section 6.2 Evaluating Fuzzy IDEAS as Analytical Method, evaluation shows that my method captures each subjective experience of listening quite differently. My process of collecting qualitative listening observations about an individual experience of the music provides some (rather than none) information directed to making sense of the music. Additionally, the information is more easily available, and more easily analysed in a process consistent across each listener, even though each listener's information is analysed on its own terms. I am not trying to make conclusions about how people listen in general, or what aspects of sound they hear while they are listening. However, the basis of this thesis is that using fuzzy logic to characterise an individual experience of listening to music enables us to visually represent the lived experience of music. Each listener is observing the music and describing its properties. The analyst draws these qualitative listening observations together to produce fuzzified data based on the analyst's initial insights about the specific attributes, such as Texture and Reflective Events, that could effectively categorise this listener's experience and can be used to make sense of this music.

Composers simultaneously create the conditions for making sense of events which are still to take place, as well as 'recall' previous events, whether through complete reproduction of the original events, or allusion to previous events by replicating several features to point back to the original events. Thus, while the particular value that each feature takes at this moment in time is somewhat important in itself, the real significance lies in each feature being a component of the final product. In music, there are usually several possible solutions at a moment in time, each of which may affect different attributes, yet which may be equally as valid in the technical logic of the music being composed.

Multidimensional thinking is an intrinsic part of a composer's work. A composer makes decisions at the detailed elemental perspective, i.e. decisions about the construction of the individual sound events that together form the piece of music. The composer also makes decisions about the design of the sound of the music from

a time domain perspective, i.e. how all these attributes² and variations in their constituent features combine over time.

Time is an essential part of music composition, and the impact of the sound of the music on listening. However, fuzzy logic is an essentially static theory, as it has been developed for computer programs to calculate the optimal solution to a set of fixed rules at a given moment in time. These computer programs operate iteratively, moving from one sequence of calculations to another stepwise, outside of real time. As Elkan observes, fuzzy controllers typically do not record history which is required for recall of prior events, although knowledge-based systems, such as computer-aided medical diagnosis, retain knowledge about the current state of symptoms in order to produce the next request for clarifying information or the final diagnosis (Elkan, 1994:47). The problem of memory recall exists even within ‘dynamic programming’ which provides a systematic technique for making decisions based on a number of input parameters that are likely to vary over time (Bellman, 1966). However, even though dynamic programming may use fuzzy logic algorithms³, or nonlinear equations and continuous variables to generate parts of the solution, dynamic programming can still only generate solutions linearly, iteratively, at regular time intervals, whereby the previous decisions produce outcomes that are then factored into the next decision. As a result, there is little in fuzzy logic, including its dynamic versions, that is uniquely suited to analysing processes over time. Given that time is a crucial process in making sense of music, I have addressed this by documenting time in the qualitative listening observations; then mapping the fuzzified data across this crisp time domain.

Fuzzy IDEAS simplifies the actual music by using only documented qualitative listening observations converted into sound events, and by quantising the time-points of the fuzzified data to fixed time intervals. As mentioned in various discussions earlier in this thesis, programmers of machine-listening software also need to simplify music to fit the limitations of their programming code. This

² Some psychoacoustic studies, such as Korhonen, Clausi, and Jernigan (2006), measure up to 18 different technical attributes of music that potentially contribute to the impact of music on listeners.

³ Fuzzy algorithms (Zadeh, 1968) have been successfully applied to dynamic programming when solving other decision making tasks primarily in business management environments (Bellman and Zadeh, 1970; Esogbue and Bellman, 1984).

requirement to reduce the amount of data means that the extreme values of some attributes may be obscured by using summary statistics, such as the average value of the series, to represent the complete data set. By comparison, all details and relative values of features and attributes documented in every qualitative listening observation are maintained in the fuzzified data.

I use the term 'complexity' throughout this thesis to refer to several different but related aspects of the fuzzified data. First, the degree of complexity is directly related to the number of attributes documented in each multi-dimensional description of an individual sound event. As discussed elsewhere, the potential number of attributes and features for each individual sound event is large, while the documented number of attributes for each individual sound event will be fewer due to challenges in rapidly and continuously documenting the listener's perceptions. This first type of complexity refers only to the number of attributes documented for each sound event, although in a similar vein, recognising that the complete sound of the music is even more complex than the documented sound events. Second, I refer to individual sound events as being more complex if their descriptions are truly fuzzy, instead of being completely well-defined with crisp boundaries. Thus, sound events are considered more complex if they are categorised as belonging to two or more feature sets in an attribute.

Similarly, those sound events classified as Partially Indeterminate Events are thought to contain a higher degree of complexity than sound events not classified as Partially Indeterminate Events. This complexity is ascribed because the documented indeterminacy directly contains references to contextual information, even if the contextual information has not been separately documented in other sound events. Although it is self-evident that the observed qualities of each sound event are impacted by its context, no other attributes except for Reflective Events, directly and openly contain contextual information.

a. Application of logical operators in fuzzy ideas

I use visual analysis of the analytical charts to locate the important attributes and features in the experience of each piece of music. I have not used the typical fuzzy logic mathematical operators⁴ to infer the logical implications of the fuzzified data. As Zadeh observes, the term ‘fuzzy logic’ is used in two different contexts, which he terms a narrow sense and a broad sense (Zadeh, 1994:43). Fuzzy logic used in a narrow sense refers to a specific extension of multi-valued logic that enables reasoning with approximate values. In the broad sense, fuzzy logic refers to fuzzy set theory, or the “...theory of classes with unsharp boundaries” (Zadeh, 1994:43). Rather than constructing a membership function for further numerical calculations as required in fuzzy logic systems which control autonomous machines, my use of membership values gives a relative indication about how much each event is thought to belong to its relevant fuzzy feature sets⁵. In *Fuzzy IDEAS*, membership values represent points on a continuous rating scale of ‘truth’ or degree of belonging to a feature set. In as much as our real number system can allow a continuous scale, given that very small numbers are still discrete points, what I mean by continuous, is that there are no fixed point values from which a selection must be made. Rather, the analyst can decide on the distance between point values of sound events in the same feature set. At present, these membership values are only assigned during the coding of the fuzzified data. The analyst translates the subjective judgement of the listener into a membership value when particular items are documented in their qualitative listening observations.

One of my analytical charts titled ‘Max-Min Attribute Complexity across the Time Domain’ is a refined version of the visual representation of the experience of the music at the attribute level. In the fuzzy logic literature, ‘min-max’ or ‘max-min’ are frequently used abbreviations for the fuzzy logical operators of intersection or union of fuzzy sets. In the literature, these operators are frequently described by means of

⁴ Set intersection and set unions frequently represented by t-norms and t-conorms, are typically used in the fuzzy logic literature dealing with industrial control decisions, or for mining of large databases for population-wide inferences.

⁵ Sometimes uncertainty regarding the degree of membership will be specifically documented in qualitative listening observation, or sometimes the description of the sound will itself be vague or uncertain as to the relevant feature sets for its classification. Thus, particular membership values could be assigned by different analysts, as well as different listeners.

geometric diagrams (visual representations). Geometric diagrams are used to represent the application of these fuzzy logic operators, although algebraic formulae (in set theory notation) may be used to determine the actual values at the maxima and minima of membership functions of the relevant fuzzy sets.

I have loosely borrowed ‘max-min’ from the fuzzy logic literature, because my visual analysis is similar to conventional analysis of fuzzified data that also searches the contours of a visual representation for the largest and smallest values. I do not use the fuzzy set operators of maximum or minimum membership values, nor mean to imply that my ‘Max-Min’ analytical chart is the result of applying those operators to the fuzzified data at the feature set level. Rather, the purpose of this analytical chart in *Fuzzy IDEAS* is to highlight which Attribute Combinations occur at the peaks and troughs in the contour of the original visual representation of Attribute Complexity across the whole of the music. The peaks (Max) occur at the time-points of the most complex events, while the troughs (Min) occur at the time-points of the least complex Attribute Combinations.

Interestingly, authors of other applications of fuzzy logic to music problems, apart from the design of control mechanisms for automated performance/playback, do not refer to fuzzy logic reasoning methods, i.e. the use of these technical operators, in their published reports⁶. However, I argue that there are several plausible reasons for this. Some authors want to maintain their intellectual property for commercial reasons. Further, as mentioned above, applying fuzzy logic to control the operation of equipment is different from applying fuzzy logic to analysis of music because the two types of problems do not use the same fuzzy logic mechanisms. Designing practical mechanisms to control equipment requires good definition of the way the relevant fuzzy sets interact. This is the case for fuzzy logic controllers in automated music performance. When it comes to music applications of fuzzy logic in automated score analysis, fuzzy logic operators are not usually applied, because similar to *Fuzzy IDEAS*, the application of fuzzy logic is to classification, rather than control.

⁶ As Zadeh observes is also the case that classical reasoning mechanisms (binary logics) are rarely used other mechanical control theories (Zadeh, 1994:43).

There are several other reasons I have decided not to use conventional fuzzy logic operators - union and intersection of fuzzy sets - to draw conclusions from the fuzzified data in *Fuzzy IDEAS*. As Wang, Tan et al observe “...the practical applications of fuzzy logic deal mainly with methods of generating fuzzy sets, and the meaning of these methods of fuzzy quantisation” (Wang, Tan et al., 1994:40). As a result, fuzzy logic operators are not fixed and domain independent but as Wang, Tan et al., go on to explain “In fact fuzzy quantisation has been introduced precisely for the purpose of generating domain-specific quantities. The numerous forms of fuzzy operations suggested in the literature were created to cater to the domain-specific needs” (Wang, Tan et al., 1994:40). The fuzzy logic operators are primarily a way to investigate and locate the similarity and differences between the data contained in each fuzzy set within a single attribute. I have elected to maintain the complexity of information in the range of attributes reported by the qualitative listening observations, rather than simplifying each event to a single attribute.

Importantly, these logic formulae produce numeric results not directly pertinent to the goal of providing evidence to illustrate the personal abductive process of making sense of each piece of music. Rather, these logical operators are more relevant for testing hypotheses in an inductive scientific method. It is beyond the scope of this thesis to perform testing on multiple listeners. These types of tests ask different questions, because the scientific model of inductive reasoning works to test hypotheses about the general population by providing evidence based on a small sample of that population. In this type of empirical research, using fuzzy logic operators on the aggregated data across listeners or pieces of music could be useful when analysing responses. Further, various fuzzy pattern-recognition, clustering, and related techniques, as well as regular multi-variate statistical techniques can be employed to address the type of questions that can be asked of this sampled group data. However, the research questions in the study⁷ presented in this thesis are quite different. Therefore it is unnecessary to use fuzzy logic operators rather than work with independent attributes.

⁷ However, as will be discussed in Chapter 7. The Future of *Fuzzy IDEAS*, *Fuzzy IDEAS* could be useful for conducting these types of statistical tests to make population-wide claims.

b. Transition Pairs

Transition Pairs are one way of looking at the information conveyed by the attributes of adjacent sound events, particularly from the perspective of perceived (both consciously and without awareness of) formal design. Transition Pairs provide information on one potential marker of compositional form, i.e. temporal design, along with technical attributes of these markers. It is possible to conceive of Transition Pairs being like the analysis of harmonic progressions as denoted by adjacent chords within tonal music, regarded as indicative of the formal structure of the music and its progress towards a conclusive ending⁸. Even though a formal design may not consciously affect how the listener makes sense of the music, the composer will have made their music unfold over time by using design principles of one type or another. However, Transition Pairs go beyond looking for sections demarcated by Silences, into looking for pairs of Attribute Combinations, seeking sound events that act as pointers to formal deployment of sonic materials throughout the music.

Assessing Transition Pairs begins with a comprehensive mapping of the changes in Attribute Combinations for every adjacent pair of sound events. This mapping is then summarised by counting the number of variations. In Chapter 5, Section 5.2, as part of my visual analysis of the fuzzy visual representations, I use the number of variations between the attributes of adjacent sound events as a way of measuring the amount of continual variation, or direct repetition within the piece of music observed by the listener. In fact, any repetition becomes particularly significant precisely because it has been documented, and therefore has stood out in the experience of the music in some way. Because listeners adapt their hearing responses to particular music, especially when there are repeated patterns of events, what is then documented is the unusual occurrence, the something new rising out of what has now become familiar. On this basis, we would expect Transition Pairs to be different, rather than the same.

I have assessed Transition Pairs only at the attribute level, rather than at the detailed feature set level, as a start to assessing the amount of variation. If there is

⁸ For instance, in tonal music, silences are preceded by cadences, i.e. prescribed harmonic progressions for given points in the music, which denote a particular formal structure.

no repetition at attribute level, then there will not be any repetition at the feature set level, as they are in a hierarchical relationship. It might be fruitful to look further into the feature sets for those Transition Pairs that are replicated in the listening experience. However, that is beyond the limits of this thesis.

There remains the question of whether elapsed time between sound events impacts on the value of assessing Transition Pairs. Analysts employing machine-listening methods can easily use Transition Pairs as a guide to the inner working of the music they are studying because they digitally document the attributes of most or all events within the music⁹. Cope's research into identifying composers' styles is also concerned with finding markers which he says help listeners identify the temporal design of individual pieces of music. Cope who works with MIDI files containing information on pitch and rhythm of every note in score-based music, calls these markers 'earmarks' because they are "...gestures which seem to foreshadow important structural events" (Cope, 2000:183). Cope goes on to say that these earmarks are location-specific and identify a lot about structure. These structural markers appear as gestures, which in *Fuzzy IDEAS* would be identified as sound events, such as upward arpeggiations followed by a trill. Most importantly, these earmarks only appear immediately after or immediately before another important event in the music. Therefore, they typically only occur once or twice in a single movement or piece of music (Cope, 2000:185). Cope's research indicates that Transition Pairs can be a useful way of identifying structure, and that with respect to structure there is little problem with only identifying sound events which occur at widely spaced time intervals.

Reflective Events are included in counting variations between Transition Pairs even though they are not a technical aspect of the music, because not all identical progressions of technical events will necessarily produce Reflective Events. The qualitative listening observations are descriptions of moments in the experience of the music that stood out to the listener in some way as significant. Some of these moments will include conscious thought responses, as well as technical descriptions of the sound of the music. Occurrence of a Reflective Event is a specific quality

⁹ Some examples include comparing pieces of music for research about the development of a composer's personal style over years (Cope, 2000), or a comparative study of how recordings of popular music have evolved over time (Serra, Corral et al., 2012).

arising from the technical attributes of the actual event and the events preceding it. The occurrence of a Reflective Event will also influence the perception of succeeding events; hence, Reflective Events are pertinent to the discussion of transition and the effect of the succession of events on ideas suggested by the music.

c. Comparison with other methods for capturing uncertainty

Typically, in conducting qualitative research in the social sciences, participants are asked to respond on a predetermined rating scale, in which the step-points are often given natural language labels, such as 'slightly melodic', or 'very polyphonic', and hence are by definition 'fuzzy sets' because natural language labels are not numerically precise. To make the data quantifiable, these rating scales are usually converted to crisp numbers then applied in the earlier mentioned statistical tests on multiple respondents. As a result, large numbers of responses can be collected and analysed for research that address population-wide generalised questions.

There are several other reasons I do not consider rating scales to be appropriate for my method. The aim while collecting the qualitative listening observations is to focus on the music to a maximal amount, rather than being distracted by the mechanism for documenting the listener's responses. The problems with rating scales begin with the participant deciding for each of their individual qualitative listening observations which are the most appropriate categories on the rating scales. Using predetermined categories runs the risk that respondents dither, taking time to decide if this sound event is 'slightly melodic' or is it 'melodic' without being able to score how much they think this label is actually true, or that they think this particular aural event belongs in both fuzzy sets. These scales do not capture the uncertainty in classification inherent in the perception of some sounds.

Rating scales are predetermined by the researcher, which means responses are predetermined in several ways, rather than being more open-ended. The relative values are given at predetermined equal intervals, whereas the music might emphasise multiple and detailed nuances towards one end of the scale only. Classification into predetermined rating categories may not capture these nuances. In addition, the attributes and features of the music are set out in front of the respondents, whose hearing may be focussed on different things, or they may want to describe their experience differently from the terminology employed by the

researcher. Using rating scales is contrary to the process of sense-making built into *Fuzzy IDEAS*. The method is designed to be abductive, allowing the manner in which the music makes sense to rest with the individual analyst, based on supporting evidence from the qualities of the music observed by an individual listener, rather than on qualities of the sound of the music predetermined by the researcher.

To set out the multiple attributes of music in multiple rating scales that must be tracked and filled in over time, can easily imply to the listener that they must attempt to address every detail on the page, whether they are relevant to them or not. Even with clear instructions to document only what is relevant to this personal listening experience, there is still a large cognitive load in terms of scanning the page to find the relevant scale and the desired step-point and to write answers while listening attentively. This can lead to a distorted response. I suggest it would be more accurate to leave the listener to decide what attributes or features are catching their attention, as well as an open-ended process for capturing what I have termed ‘cognitive responses’, which are those events that document thinking responses rather than direct perceptual responses. It is more accurate to make notes only about those items that consciously occur to the listener, instead of being faced with a constant stream of potential possibilities that someone else has thought of in a completely constrained response format.

No matter which tools are used to record the qualitative listening observations, any recorded responses still need be analysed. Collating, and subsequent analysis of, the data captured by rating scales might be more efficient as it can be automated more easily, instead of the manual coding process of fuzzifying the qualitative listening observations. However, in my application of fuzzy logic in *Fuzzy IDEAS*, this is simply a different, yet more effective, location of effort. With rating scales, confusing and perhaps irrelevant effort is placed on the listener as they negotiate an enormous cognitive load, difficult under the conditions of listening attentively to music in real time. Instead, with my fuzzy logic method, the effort is placed on the expert coder, leaving the listener with a smaller cognitive load while recording their qualitative listening observations.

Since the initial conception of fuzzy logic by Zadeh and its application by other researchers in the intervening decades, various new ways of dealing with

imprecision in classification have been developed. In particular, the theory of ‘rough sets’ has become another widely recognised method for dealing with uncertainty, however, following Efstathiou’s principle¹⁰ that if a particular method delivers on the goals of the researcher, then there is no need to investigate other methods. I have established that fuzzy logic principles are a useful way to meet my objectives of providing visual representations which capture the nature of subjective responses, technical features, and their interactions, all of which contribute to the process of making sense of avant-garde music. I am not arguing that fuzzy logic is better or worse than other methods of classifying and working with ill-defined objects. In fact, doing this kind of comparative analysis would result in a completely different thesis focussed on the pros and cons of each method, rather than following through on the problem of developing a method that explicitly addresses the intangibility of music and the subjective personal experience of listening to music as a way of making sense of this artform, music.

¹⁰ Efstathiou’s rule-based method for multi-attribute decision making (Efstathiou, 1984) is a two stage process based on fuzzy logic using natural language, taking place in an iterative learning environment. Her complete method is designed to be immediately comprehensible, espouses ethics of including the decision maker(s) in the entire process, and is entirely human oriented. Indeed in simple cases, computers and numerical calculations (whether based on fuzzy logic or not) may not be necessary, because the computation can be done entirely in natural language, as Efstathiou says “...with pencil, paper and common sense” (Efstathiou, 1984:313). Efstathiou’s model is based on the proposition that it is not practical for all possible problem solving methods to be tested. The meta-question then becomes one of deciding which solution method to use for any given problem taking into account the environment in which the question is being posed.

The first stage addresses this meta-question of finding an appropriate methodology for the generation of potential solutions to the underlying problem at hand. This is done by asking a series of questions to the human decision-makers to determine the issues the solution method must address if it is to provide useful solutions to the underlying question (Efstathiou, 1984:313). The iterative process she proposes, teases out the essential attributes that the method must hold in relation to that specific problem. As a result, the solution method ultimately chosen automatically provides a satisfactory and useful answer to the original question.

In relation to *Fuzzy IDEAS*, because my requirements for a new method may be explicitly stated as: “the solution must be a transferable and repeatable method of context dependent, multi-attribute decision making, which is inherently meaningful and transparent, while being capable of handling imprecision and vagueness”. The response is that a satisfactory and useful method for my underlying question of making sense of avant-garde music is derived from principles of fuzzy logic because a method based on fuzzy logic satisfies all my requirements. As a result, there is no need to look any further.

The second stage of her method is a process for ranking the various solutions generated by the methodology selected in the first stage of her model. This occurs through the decision makers ranking each possible solution against the complete range of attributes to be addressed in the solution. In relation to *Fuzzy IDEAS*, this is the process of deciding which potential idea best makes sense of this single experience of listening to music. Because of the processes involved in addressing the meta-question in the first stage, we know that this result intrinsically takes into account the specifics of the initial problem.

However, I will specifically discuss probability theory here because its development considerably pre-dates fuzzy logic, hence probability theory has become a well-known and typical way of dealing with uncertainty. Both fuzzy logic and probability theory are systematic attempts to deal with uncertainty, but deal with different aspects of the problem. As discussed in Appendix F, Section F.3 Distinguishing Fuzzy Logic from Probability Theory, probability is about the likelihood of particular, yet well-defined, events occurring, such as determining which feature is more likely to occur at any given moment¹¹. Probability theory still relies on binary, either true or false, thinking¹², while fuzzy logic is multi-valued so that many partial truths can coexist, thereby capturing the range of possibilities contained within particular events, as they exist in their imprecision and ambiguity.

Probability models cannot adequately represent the design and aesthetic aspects of creative decision-making required in music composition. As Jacob observes “...the intelligent part of composing is in choosing the good over the bad” (Jacob, 1996). Automated composition engines which use probability models to emulate human compositional decision-making rely on controlled random number generators¹³ to produce variation in sound events. However, as Cope observes, 'randomness' is described by complexity, lack of patterns, and irrelevance, so that it has no perceivable logic (Cope, 2005:53). Even though “...creativity is also unpredictable, [yet] creativity often turns out in hindsight to be the most rational way to have proceeded. Reverse engineering even the most complex creative processes demonstrates this rationality” (Cope, 2005:57). While, as described by Cope, probability theory is clearly lacking in design sensibility, fuzzy logic methods are little better at innately handling the creatively innovative. However, as Elsea has demonstrated within the limited scope of sequential chord generation (Elsea, 2011),

¹¹ A related observation is that the exact values of probabilities of specific events can only be determined once we already have some prior information about the probabilities of occurrence, i.e. the predetermined probability distribution(s) relevant to the overall population of events, of which these individual events are members. Probability theory does not give us probabilities from scratch. By comparison, fuzzy membership values are co-generated with events as they occur.

¹² As discussed previously, binary classification requires ‘quantisation’ or rounding off to the nearest unit. For example: this aural event, according to binary thinking, must be classified as either one or other of ‘noise’ or ‘music’, so that event clearly is classifiable as a yes/no answer, for example if this sound event has 75% inharmonic overtones then it must be ‘noise’, it cannot be ‘music’. In this process, information is lost, and complex things are over-simplified.

¹³ ‘Controlled’ means using some formulae to limit the output of the random number generator by limiting the range of numbers within which it operates.

fuzzy logic systems can operate successfully in time domain design if there is an external control template to guide decisions at predetermined time-points.

6.2 Evaluating Fuzzy IDEAS as Analytical Method

As well as four demonstrations of the method presented in Appendices A-D, I investigated my claim that *Fuzzy IDEAS* is repeatable and transferable between listeners by conducting a small evaluation on three other people. I followed the test procedure documented in Appendix H, in which the three participants were asked to listen and record their responses to the same piece of music, *Scharlachrote Buchstaben* (Heller, 1984). In the evaluation, participants are presented with the title of the music, the composer's name and date of composition, then the music is played through from beginning to end while they note down anything that stands out to them in the music, whether qualities of the sounds, or their own ideas and thoughts about the sound of the music, as well as the time points of their qualitative listening observations. Following the collection of the qualitative listening observations, the respondents are requested to make notes, on the form provided, about how the music they have just heard "makes sense" to them. Later, I applied my fuzzy logic coding taxonomy to produce fuzzified data from these qualitative listening observations. I then mapped each of the participant's fuzzified data into visual representations and analysed those representations for evidence to support an abductive conclusion about how that music makes sense.

Recall that the primary purpose of *Fuzzy IDEAS* is to establish what it is in the music that enables us to make sense of a single experience of listening to this music. Therefore, the primary purpose of the evaluation is to examine the utility of the method in practice, not to establish the validity of any conclusions about this particular music. Because of time constraints, I limited the evaluation to three participants, one an untrained but enthusiastic listener, the other also untrained but who dislikes avant-garde music, and the other a trained composer of contemporary art music. They were all tested using only one piece of music: *Scharlachrote Buchstaben* (Heller, 1984). Thus, this small evaluation would provide an indication of the utility of the method across listeners and, albeit limited, a comparison of the resulting visualisations for the same music across different listeners.

The evaluation is to test the analytical approach I have set out in this thesis¹⁴. The goal is to establish proof of concept that *Fuzzy IDEAS* is transparent, systematic and useful in practice. To summarise, *Fuzzy IDEAS* is a three-step process: the initial collection of the qualitative listening observations, followed by coding the qualitative listening observations into fuzzified data and mapping the fuzzified data into a series of visual representations of that personal experience of the music. The final step is analysing the visual representations and other abductive hypotheses generated during the listening experience to find the abductive hypothesis which is best supported by the available information and makes the most sense of this single personal experience of the music.

The evaluation is an indicative proof of concept. This is because it would take me too long to teach another analyst the coding method and get them to perform their own analysis of music using *Fuzzy IDEAS* in totality. On the other hand, if I am simulating a composer testing their music to see how ordinary audience respond then I need an ordinary listener for the next part of the evaluation. Because it would take some time to teach a student composer how to use the method, because they would have to learn about the coding taxonomy and other technicalities of producing the visualisations, doing that test is out of the question for now. Instead I decided to use myself as the analyst coding the test results because I already know how to use the method.

My aims for the evaluation are to:

- discover any problems with the test method in terms of the physical administration, such as the playback technology and time-keeping devices
- test the self-report methods I have devised with listeners with different backgrounds in avant-garde music
- investigate whether the self-report methods I have devised impact on listener appreciation of avant-garde music
- determine whether collecting listening information assists these participants make sense of this music

¹⁴ In particular, I am pointing to the utility of fuzzy logic descriptors as being broad enough to capture all types of responses, and value of the fuzzy visual representations as a source of data for analysis.

- evaluate my fuzzy logic system of classifying these self-reported listening observations
- gain some insight into how long it takes to code and map qualitative listening information from another listener into visual representations of their experience of the music
- determine if the qualitative listening observations from other listeners provide useful information to enable an analyst draw conclusions about how the music made sense to those listeners.

In evaluation, the first step is to get some idea of the participants and what they bring to the test situation. Here, the participants are all middle-aged adults who work at the university, but not all are academics, nor work in the music department. Their music background was varied. The first participant (TS1) was a listener with minimal music training, self-described as a novice, although she had four years of piano lessons as a child. TS1 describes herself as “loathing avant-garde music, even though she has heard a lot of it over the years, being a good friend to musicians by supporting their performances.” By comparison, TS2 is also a non-musician who likes avant-garde music, especially avant-garde pop music. “I enjoy the surprises and the skill avant-garde musicians display in communicating complex ideas.” She has heard “only some avant-garde music”, yet in a vast array of settings from “concerts, galleries, to personal listening in the car.” The third participant TS3 is a trained musician/composer who “actually likes/enjoy avant-garde music, although some of the personalities of the avant-garde have been overly serious about music” and he has heard “volumes” of it in a vast array of settings.

a. Evaluation of the qualitative listening observations

As part of evaluating the complete method, we need to evaluate the process of collecting information about the listening experience. All three participants advised me, and it was also my own experience, that the active listening required to collect the qualitative observations all helped them appreciate the music and enhanced their listening experience, so that even the reluctant listener said that they found more in the music and had enjoyed the experience more than expected.

TS1 replied that “It made the first one [piece] less boring. I paid more attention than normal and ‘saw’ images.” Further benefits in doing this documentation were

described as “Yes, I had to really focus on the music sounds - rather than just get annoyed.” TS1 responded that this experience of avant-garde music “wasn’t as bad as I thought it might be.” Further, doing the test meant that this experience of avant-garde music was different and better than other concert experiences of avant-garde music because “Sitting with table and chair made focussing easier. No sense of atmosphere made the music more ‘present’ for me.” Particularly that it was “Better - wasn’t as bored. Was still a bit annoyed, but not as much.”

Another participant spelt out that they found it difficult being in the test situation rather than just listening in normal circumstances, yet still found something positive in the experience. TS2 replied that “I enjoy being curious and learning. I have been introduced to a new composer. I’ve been encouraged to listen reflectively and capture the thought clouds. Makes me miss journalling.” “It was different than other times I’ve listened to avant-garde music because I had a task to complete, not just enjoy the music. Writing, the stop watch, being observed and the test environment all made it different, made worse by “no wine, no audience, no choice of music, no knowledge of composer.”

TS3 found the process of collecting the qualitative listening observations “a worthwhile experience. It helped me to listen with ‘articulation of listening’ in mind.” “Yes, articulating ideas about music is always beneficial to me, and this was like a focussed opportunity in that regard.” “I think this is actually a very good tool.” When asked about this experience of listening to avant-garde music, TS3 replied “Beneficial in many ways enjoyable, expanding, engaging and community-making.” Confirming it was definitely better than other times they had listened to avant-garde music due to the nature of this specific music, because “I didn’t feel that it was tiresome/too entrenched in a ‘school’ (like serialism, for example). Interestingly, I didn’t feel the composer would be boring or arrogant.” “The musical expression was clear, the inventiveness was solid, the music was engaging yet not tiresome.”

The process of collecting the qualitative listening observations also assisted each of the participants make sense of the music. Their initial expectations of the music after considering the title and composer were quite varied. All reacted to the title being in German without English translation and the consequent lack of information but in their varied ways, this contemplation of the title set them up for the listening

experience to come. All respondents were keen to discuss their responses to the music with me in detail following the listening test, as indicated by their spontaneous talking so that I had to direct them towards writing their responses. My post-study interpretation of their responses to my direct questions about how the music made sense showed that they all had formed some impression of how the music made sense¹⁵ at the time of listening...therefore despite their preconceptions about avant-garde music, what they heard was more than just 'noise'.

The process of writing and self-reporting of their qualitative listening observations clearly had very positive reactions from the participants, but only one was uncomfortable with writing her responses. TS1 was quite keen to talk rather than write their expectations and thoughts about the music, except for the actual listening part, when TS1 just wrote constantly. Initially, they wanted to talk about their extensive experiences with avant-garde music and their loathing for this style of music, which led into wanting to talk about their responses to the title of the music. In particular, TS1 really wanted to discuss the concept of how they could make sense, to them it meant finding 'meaning' in the music.

By comparison, TS2 wrote they had "...no problems, although it was hard to catch the mindscape of images and the sound details. Left brain vs right brain perhaps." "I find it a very curious task, uncomfortable due to facing the unknown surprise. Also very interesting, it sparks many ideas and self-realizations. No musical vocab, shy sharing ideas/opinions etc." "I found the process surprising. It felt like a high-school exam., painless but uncomfortable, as I don't know the composer's work. That said, I enjoyed the music, so it was enjoyable, interesting, fascinating." TS3 wrote that they had no problems with the test process, made no comments on the questionnaire, did not miss any questions, and just wrote his answers without any questions. TS3 had no problems in documenting their listening experience, even without reading glasses. TS3 said they really enjoyed the opportunity to articulate personal responses to music. When specifically asked if there were any drawbacks to the method, TS3 said there were none.

¹⁵ This was still the case for TS1 who had difficulty in understanding the concept behind 'making sense', but was comfortable writing about the 'meaning' the music had for her.

However, I am aware there are some issues in the testing procedure for the evaluation which may have affected these listeners' responses. As mentioned previously, the listeners were conscious of being under observation, which may have affected their responses. This self-consciousness could have been the reason all the respondents were keen to know how long the music would last. The listening setup was different from the one I used for the demonstration analyses. The music was played through a laptop computer rather than a CD player. This meant participants needed to keep track of the beginning of the music and subsequent time-points through a digital stopwatch on a mobile phone¹⁶. This could be a problem for synchronising initial and elapsed time-points across participants. Using a laptop computer also meant I needed to have a prearranged signal for the end of the music because there were no built-in visual signals from performers, or audio cues such as clapping, or the CD player moving on to the next track. Participants had no access to any images or written documentation about the music other than information provided by the testing situation. They did not have the minimal visual information available from a CD cover. Participants would be listening to a piece of avant-garde music informed by only the title, the composer, the date of composition and any other information they knew before listening to this piece of music.

b. Evaluation of the coding taxonomy

The impacts of technology manifested in diverse ways. Manual data entry and creation of the visualisations, although based on digital tools, still relies on consistent technology to produce consistent results. Using *Fuzzy IDEAS* at different times with different computers relies on different versions of software which have different capacities for data manipulation, even in tasks as simple as cutting and pasting graphics into other documents, let alone constructing the complex charts required to implement *Fuzzy IDEAS*. Even displaying the visual representations is open to the whims of technology and the colour rendering of individual computer

¹⁶ Although I could have let the participants note the elapsed time from the media player interface on the laptop, the display also automatically includes the total duration of the music and a visual indication of how much of the music has already played. However, this additional time information would have voided one of the principles I was using in collecting the qualitative listening observations: that the listening take place in a concert-style setting, which means that the listener would have little practical indication of the duration of the music, nor how much is remaining to be played.

monitors and printers; an extreme but actual example is, what appears to be highly contrasting colours on a computer display, print out as monochrome in hard copy.

On occasion I found the participants' handwriting difficult to read, so I had to make a best guess at some words. However, usually by the end of each coding exercise this was no longer a problem as the same words were legible in later parts of that listener's responses. I decided not to recall the participants to check the accuracy of my deciphering because this would not necessarily be possible in other implementations of *Fuzzy IDEAS*.

The setup for measuring elapsed time in the evaluation meant there were problems with cueing the start of the stopwatch timer with the start of the music. Because of the problems of identifying the end of the music without proper performance cues, I decided to make the Silence observation at 13'20" the final observation for this music. This meant that when I noted that a participant had observed a time point for the end of the music later than the actual duration of the music¹⁷, e.g. 10" after the actual end of the audio, I moved the quantised time points for all this listener's observations back by 10". Recalling the process of rounding down each time point to the nearest 5", then removing the extra 10" cueing latency meant that the Silence at 13'20" is now at the same time point for all participants.

There were other issues with coding the qualitative listening observations into sound events with precise time points. For instance, TS1 elided some of her qualitative listening observations. These three qualitative listening observations include both Silences immediately followed by Sound Event descriptions. There seem to be two options for dealing with this problem. Either, to make this into two discrete events with different time points, or to do the unusual and include both in the one sound event¹⁸. Because the first solution would give a less accurate idea of

¹⁷ The duration of the music as measured by the duration of the audio file may not be identical, but the duration of the audio file provides a concrete and repeatable marker similar to the movement of a CD player from one track to another.

¹⁸ Specifically, I decided to number these qualitative listening observations as two sound events, but in the time series visual representations they are shown as one sound event but with Partially Indeterminate Events qualities. This will impact on the frequency and proportional calculations in the analytical charts because the numbering of sound events reaches 33, rather than the 30 in the time series representations. This new total as the basis for analysis is the same as if they had been written out as separate events in the qualitative listening observations, which maintains some consistency.

the timing of events, I have elected to remain with the unusual and thus elide the two in the visual representations as they have been in TS1's qualitative listening observations. I resolved this problem for these unusually elided events by giving them elided E numbers to make things consistent across the whole explanation, and visual representations across the different analyses. However, in the analytical charts, when counting the Attribute Combinations and Transition Pairs, I have made these proportions out of 30, because the overview statistics arise from visual inspection i.e. counting the data points in the visual representations.

One of the participants tended to make qualitative listening observations but without corresponding time-points. For, example, there is a Reflective Event between 8'00" and 10'20", both documented time points with qualitative listening observations, yet this Reflective Event is well described without a time point, so I have interpolated it halfway between the two documented time points at 9'10". This of course can produce artefacts, but they would be produced no matter where the time-point for that sound event is located.

Converting the qualitative listening observations for this music into fuzzified data highlights a particularly distinctive aspect of using this method with term sets provided by listeners. One participant used words such as 'clean statement' and 'toccata-like' to describe parts of the music. As I am a composer, these words have specific attributes associated with them, which I can translate into fuzzy sets quite easily¹⁹. This participant also used the word 'clock-like' which has inbuilt music associations with a particular tempo, accent pattern, and articulation, none of which are specifically spelled out in that participant's qualitative listening observations. Rarely are there music theoretic technical descriptions of sound in the qualitative listening observations of the other test participants, but rather terms such as 'plinky-plonky sounds' or 'the sound is more complex and full', or the use of 'gone' instead of Silence, while other words like 'quiet' and 'still' can imply that the music was soft and tranquil rather than a Silence.

¹⁹ For instance, 'clean statement' refers to Texture and means a straightforward single line of notes or chords, while 'toccata' is only used in music (as far as I know) and it means a rapid virtuosic flurry of notes, again a Texture and Tempo descriptor.

Converting each listener's terms into music theoretic terms means that I can use my existing graphic tools as templates. In some cases, it is possible to discern the music theoretic terminology implied by these words, particularly at attribute level, but at feature set level, these terms remain ambiguous, which in some instances has resulted in simultaneous classification in several feature sets. In other cases, it has been necessary to completely rename the feature sets in an attribute because the particular terms have been used so frequently by this listener, these terms have taken on their own importance. In other instances, music theory was completely irrelevant because the qualitative listening observations were evocative words for describing a narrative trajectory rather than describing the actual sounds they were hearing, while another wrote more about the images and emotional responses the music evoked than the actual sound of the music. These are completely different ways of talking about the music. Therefore, I could invent a whole new attribute for these observations – calling it Emotive Character - but instead I stayed with the rules about classifying non-technical events and classified these events as Reflective Events, all in the feature set of Free Range Thoughts.

I have also had to add in a feature set, labelled 'Unspecified', for some attributes. For example, TS1 has identified the attribute but no further information is available. The other alternative is to include this event in all the labelled feature sets, but there is no way of knowing the accuracy of this classification and it becomes misleading in relation to my argument that multi-featured events are more complex than others, simply because this sound event might not be more complex. What we have is missing information. Similarly, when selecting the feature sets for Sound Type when coding TS1 qualitative listening observations, it was impossible to tell any kind of ordinal ranking, so I made one up based on the relative sonic duration of the terms used in the qualitative listening observations.

There are many more Reflective Events in the participants' qualitative listening observations compared to my own very technical qualitative listening observations, so that any Free Range Thoughts of mine were clearly a distinct subgroup of Reflective Events. Further because the nature of their responses are open to interpretation it is difficult to know in which feature sets of Reflective Events they should be placed. As a result, I have placed each one in a number of feature sets of Reflective Events. There is no doubt they belong to this attribute of Reflective

Events, the question is which one of the feature sets. Similarly, the vagueness of description in some qualitative listening observations leaves me unsure when to code Partially Indeterminate Events. Consequently, although there are few Partially Indeterminate Events for participants, they are classified in more feature sets.

Finally, when coding the qualitative listening observations into fuzzified data as sound events, I observed that the minimum time between qualitative listening observations of each listener was quite varied. My personal experience of listening to *Scharlachrote Buchstaben* produced 47 listening observations, in which the smallest time interval between time points is five seconds, while TS2 produced 46 listening observations with the smallest time interval between time points of five seconds. By comparison, TS1's experience of listening to *Scharlachrote Buchstaben* produced 33 listening observations, in which the smallest time interval between time points is ten seconds, and TS3 produced 16 listening observations with a smallest time interval between quantised time points of ten seconds. One cause of the large difference in the number of sound events was that both myself and TS2 tended to identify sections of sounds by both the beginning and end time-points of those sections. This is different from the way the other two listeners generally responded. Separate qualitative listening observations for beginning and ending of each event means that the number of fuzzified sound events doubles compared to those listeners who simply identified that something had changed. However, I resolved to keep to my original method as set out in Chapter 5, and see what the resulting visual representations would look like. My rationale is that I should implement the method as set out, as I would expect other researchers to do. Further, I anticipate that the actual qualitative details of each listener's responses will vary from mine in many respects, resulting in different attribute and feature set distributions, so there are many other reasons for the resulting visual representations to look very different from mine.

This evaluation revealed that it takes a minimum of one week to manually code the qualitative listening observations into fuzzified data, to generate the visual representations, and then to analyse the visual representations and intermediate abductive hypotheses to find an idea which best makes sense of the music based on the available information. This is mainly because the qualitative listening

observations from other listeners are of a different order to my own, so it is almost as if I am coding the responses and designing the charts from scratch.

Even though I am using the Excel spreadsheets for coding my own qualitative listening observations for the demonstration analyses as a template, it doesn't seem to save much time. There are two reasons for this. Microsoft has updated its suite of Office programs several times since I began the project on what was already old version of Microsoft Word and Excel. The effect of the updates has been to supposedly make the software adaptable to modern requirements for producing large documents and webpages. However, for specialised work required by *Fuzzy IDEAS*, the new default settings no longer provide the fine level of control I had previously, while the complex functions are located in new places so that the updated software performs differently and, in some cases, I don't think as well. For instance, the 2013 and later versions of Microsoft Word are now set with several defaults which reduce the quality of the visual representations²⁰ when they are cut and pasted between Word documents or Excel.

c. Concluding remarks about the evaluation

Administering the test to other listeners is straight forward. The most complex part is reassuring participants about the utility of their individual answers, the test procedure, and the types of responses required. All participants wanted to be very clear about what they were listening for and what to document in their qualitative listening observations, and to know what to do if they had new thoughts before they had finished writing down the previous ones. All participants also wanted to know how long the music was going to last, articulating a variety of reasons for asking the question, but were relatively content to remain ignorant when I explained this information might affect their responses.

Once the test equipment is set up, it takes less than one hour to collect the qualitative listening observations. This includes explaining the requirements of the test and reassuring the participants about their responses. The test time can be extended depending on how much time the tester has available after collecting the

²⁰ The first default automatically compresses the digital file, thereby losing the sharpness of small-scale information. The second default setting treats all graphic objects as picture files, which results in graphics which are less crisp.

qualitative listening observations, as participants are keen to discuss their responses after hearing the music.

Documenting the experience of listening to music is problematic in that it is not physically possible for listeners to document everything that occurs/registers within the listeners' awareness. Typically, the shortest interval between qualitative listening observations is about five seconds. At standard tempo of MM = 120 this means ten actual events may have occurred between documented qualitative listening observations. This impacts on the information in each qualitative listening observation in that the listener must either group a series of sound events and document the group, or to choose the most significant parameter of an event to document. However, each qualitative listening observation still records a range of features for each attribute and the nuances between events, and overlooked details and events are assumed to be insignificant to making sense of the music²¹.

During the actual listening part of the test, all participants were actively engaged in writing, and thus not wanting to talk as well. From my perspective as the test administrator, what was particularly noticeable was that participants really wanted to talk about their responses interactively, particular in the more abductive parts of the test, such as the implications of the title of the music, and what ideas they thought were being communicated by the music. The participants were also keen to discuss the mechanics of the composition, and what I knew about the music.

Only one participant reported it was challenging doing two different tasks at the same time: listening and writing. The writing of observations seemed to be challenging on several fronts because participants feared they were going to be judged on their handwriting, spelling and vocabulary. However, without the resources to produce a well-designed digital version of the test paper, so participants could freely type in answers over a time sequence, pencil and paper still seems the most open ended process for collecting a wide range of responses. The nature of the test documentation meant modifications would be needed for vision-impaired listeners to undertake the testing.

²¹ While this appears to be a big assumption, I suggest that listeners record the details most important to them and their approach to the music as a sense-making experience. Therefore, as discussed previously (see Chapter 4, p. 146) the overlooked details are, in a philosophical sense, unimportant.

Other technical issues include potential problems arising from using different equipment and timing mechanisms in ensuring the results are directly comparable across test subjects. There is also the problem with using playback set up and music which does not contain applause or other built in cues from physical performance to identify the conclusion of the music. Determining the end of the music test relies on cues within the music only, and of course a listener's perception of those cues.

The most significant issue was in the timing of responses. Because the tests were done at different times with different pieces of equipment, there is no certainty that the different timing mechanisms have produced consistent time points across all listeners. Yet, as the tester, I knew how long the music was so I could calibrate the time points of the initial observations and final observations of a silence event, even if a participant had not been able to identify the final silence as the end of the music.

Using the test on others highlights the complexity of capturing personal self-aware responses to music, because different individuals have a different degree of awareness and capacity to verbalise and write down responses. Further, as observed in earlier chapters, the descriptors each listener chooses will be impacted by many factors. Writing up the table of Reflective Events and Partially Indeterminate Events as the first run-through of the qualitative listening observations is way to get familiar with this listener's interests and style of observation. This then informs the remainder of the coding process.

When coding the qualitative listening observations, new term sets, differing versions of software and quantising intervals, make existing templates obsolete, and require new templates for coding the qualitative listening observations into fuzzified data and creating the visual representations. The time taken for the coding depended on the types and detail in sound event descriptions. For example, those 16 observations made by TS3 took five hours; but for TS2, who had many more sound event descriptions and used an entirely different approach to describing what was happening, this has taken at least twice as long. From manually producing a complete set of visual representations and carrying out the analysis to writing up the final abductive conclusions takes a minimum of six hours, up to two days' work for each test subject. The writing up of the analytical experience and challenges of coding took another two hours for each test subject.

Coding all the free range thoughts lost much of the detail about the types of thoughts. For instance, TS1 was focussed on French movies and haunted mystery, while TS2 was engaged on a trajectory of emotional growth and maturation, and TS3 was describing thoughts about the compositional techniques and structure of the music. It is a point of interest as to whether the types of thoughts, perhaps making free range thoughts another cognitive attribute with its own different types of feature sets, would be more relevant and pertinent to the visual representations of the music. However, the evaluation shows that one of the main advantages of *Fuzzy IDEAS* is that whether the respondents make sense of the music based on its technical attributes, or go into a reflective state directed by their own background and preoccupations, all responses are acceptable and all responses are at least somewhat trackable. This suggests that sound is an appropriate metaphor for music and that *Fuzzy IDEAS* values all types of listening by listeners with varied backgrounds and preoccupations.

Summation

My research investigates using fuzzy logic principles to conceptualise music wholistically, on the basis that the composer must have had a reason for the existence and temporal location of every event in the music, thereby including all potential attributes of the sound and the overall formal design of the music. The purpose of this thesis is to demonstrate that fuzzy logic principles enable a comprehensive description of the sound of the music and its effects on individual listeners. Further, I demonstrate a systematic and transferable method for analysing music in terms of 'ideas' which is meaningful and useful.

As discussed in Chapter 2, established scholarship in music tends to gloss over the fundamental dimensions of music as a cohesive aural intangible artform and has different solutions to dealing with the problems of subjectivity. Fundamental dimensions of music are brought to light by avant-garde music as practice-led research. My research is founded on concepts of music as an aural/temporal form of expression of ideas; that sound is a useful metaphor for music because of its quantifiable dimensions and its inherent meanings; that composition and performance are instrumental in producing music, conceived as a complex dynamic

system which can only be perceived through listening. My research addresses the inherently unescapable subjectivity of analysis and need for a method that works with the diversity of avant-garde music.

My thesis constructs knowledge about music, through using sound as a metaphor for music, from the perspective of the listener, using fuzzy logic principles. This knowledge may be useful in the following ways:

- to move music analysis beyond its current limits of techniques in music theory or machine listening, which are both grounded in pitch, to incorporate a wholistic approach by including all elements of music that a composer uses to project her ideas
- to explore the definition of ‘music’ as an aural experience of sound over time designed to communicate any of a broad range of ideas (including, but not limited, to emotion), arising through compositional design of forms and using sounds over time, which is not limited by genre
- for musicology to address the thorny problem of reception, and its inherent inescapable problems of subjectivity, and the relationships between composition and performance
- to provide a transparent low-tech method, across genres, for including the reflective responses to music as an integral part of music analysis, which can be replicated on a large-scale sample if so desired
- to use a more realistic conception of music, derived from the sound of the music, as a dynamic non-linear system for conveying ideas. This philosophical understanding of music being constituted by many attributes with a range of truth values that vary at different times over the unfolding of the music. Composers are well aware this is more realistic than music being reduced to combinations of pitches in harmonic analysis of a score
- to provide a consistent method for documenting and visually representing individual listener’s experiences of different styles of music no matter how the music was composed
- to demonstrate that explicitly incorporating subjectivity does not mean imprecision or a lack of rigour. Using intangible listening information does not mean that information or the method cannot be verified or replicated. Listening information can be as usable as any other form of representing music for analysis

- to understand that potentially, any music can be expressive if the specific concepts, with which the music is concerned, are accurately signposted so that the listener is correctly oriented. This is particularly important because music is so often joined with emotion by non-musicians, even though music can be composed to communicate so many different types of ideas. Subjective, individual responses are inescapable when it comes to music, but they are directed and shaped by the composer...subjective responses are not everything and they are not nothing.
- to explore critical conventions, such as using 'expressive', a meaningless word used as a commonplace to stand in for many other reactions to the music. The use of this word reveals a deficit in the discipline-specific methodology of music analysis, a narrowness in thinking with respect to music's place in the arts, a narrowness of ability to articulate more nuanced reactions, and a general depreciation of a range of emotions as valid responses. The connection between music and emotion is real and powerful and is important in listening response to music so emotion should not be discounted, nor excluded from analysis.

Fuzzy IDEAS is the first to use fuzzy logic principles to provide an abductive practical application for analysing music in a wholistic way. *Fuzzy IDEAS* is completely grounded in fuzzy logic principles and philosophy. *Fuzzy IDEAS* is not limited to quantifiable, hence measurable, attributes but is open to all possible sound types and styles of music, each of which is composed to convey a broad range of ideas. *Fuzzy IDEAS* works with and reveals the range and complexity of materials used by composers in the design of their music. *Fuzzy IDEAS* requires that the ideas generated by the music, during and after the listening, be articulated as an important part of the analysis. This enables a story to be told about this music which is related to but distinctly separate from its technical details.

The evaluation clearly shows that *Fuzzy IDEAS* allows each listener to bring their own backgrounds and preoccupations to the listening experience which allows the music to make sense in a variety of different ways. A significant aspect of *Fuzzy IDEAS* is that it captures the mental responses of the individual listener while they are experiencing the stream of sound events which constitute the music. Reflective Events document the spontaneous thoughts which arise in reaction to specific events or groups of events as they occur in the music. Reflective Events include the

conscious responses, thoughts, images and moments of focussed attention on the music, along with any moments of self-awareness regarding responses to specific qualities of some sound events.

Reflective Events are an intrinsic part of the process of getting to know the music, but are quite distinct from the sensory perceptions of the physical, although still intangible, 'sound events' themselves. Reflective Events can occur at any moment during the listening experience, even in the absence of sound. As they reflect the individual response to the sound of the music, they are a significant aspect of making sense of the music.

Partially Indeterminate Events document those events which cannot be clearly classified into one or more attributes, fuzzy feature sets, or time points. Partially Indeterminate Events can arise from several sources, each of which can be implemented by the composer. For example, if it becomes apparent that a type of sound is dominant in the texture, but this occurs simultaneously with the realisation that the sound had been occurring for some time before the point it attracted attention, then it is difficult to ascribe a precise duration to this sound because its commencement was not documented. This is not primarily due to the listener's attention, but rather that the composer has disguised the initial appearance of the sound, by masking with other sounds, or being so soft, or less important than other features at that time. Partially Indeterminate Events represent a second layer of fuzziness in classification because of the uncertainty in the boundaries of the event, rather than uncertainty in appropriate categorisation.

Reflective Events and Partially Indeterminate Events can occur simultaneously, but it is also possible that one of these types of event will occur independently of the other. Reflective Events can be distinguished from Partially Indeterminate Events because they document any conscious image or thought about the music as it occurs, as distinct from documenting the technical qualities of the sounds themselves. By contrast, Partially Indeterminate Events are documented when various types of uncertainty are recognised as being present in the physical qualities of the sound rather than a thought reaction to the sound as documented by a Reflective Event.

Chapter 6 has explored and discussed two aspects of the new method. First, a discussion of my practical application of fuzzy logic principles in terms of fuzzy logic theory. Second, my own demonstration analyses and the evaluation study of the method with other listeners, shows that the method of collecting the qualitative listening observations, and the visual representations that result from fuzzifying the qualitative listening observations have particularly useful features. In particular:

- *Fuzzy IDEAS* enables analysis of music for ideas. My work shows that it is possible to analyse music in this way. *Fuzzy IDEAS* enables the comparison and contrast of different pieces of music in which it is possible to distinguish significant features which contribute to listeners' ideas, and to reveal the differences and similarities between listener responses to the same music.
- *Fuzzy IDEAS* enables a meaningful and useful analysis of music across genres, so that the same analytical method can be used on all Western art music. *Fuzzy IDEAS* reveals the range and complexity of materials used by composers in the design of their music.
- *Fuzzy IDEAS* enables fuzzy logic principles to be applied in an effective and practical way to comprehensively describe music, and the listening experience, by including cognitive responses as well as all technical attributes of music.

Chapter 7 discusses how these results can be taken up in future work, building on the proof of concept established in this thesis.

Chapter 7. The Future of *Fuzzy IDEAS*

This thesis is concerned with the utility of applying fuzzy logic principles to visually represent the complexity of a personal listening experience. Chapter 6 discussed the pros and cons of *Fuzzy IDEAS* as a useful method for investigating how individual pieces of avant-garde music make sense. Overall, Chapter 6 shows that this new method of listener-oriented music analysis has value because it captures in visual form the intangible personal experience of listening to a piece of Western art music.

The summary of findings in Chapter 6. Summation (see pp. 228-232 above) opens the possibility of using *Fuzzy IDEAS* in a diverse range of potential developments and applications. An immediately straight-forward application would be in teaching music appreciation to children and adults. However, additional possibilities range from its use in perception experiments¹ and composition pedagogy, to audience development through new marketing strategies for avant-garde music. These new possibilities are based on developing *Fuzzy IDEAS* into automated ‘smart’ technology using new technological applications of the fuzzy visualisations in order to enhance audience engagement with the music during performances.

Fuzzy IDEAS as a method, lies somewhere near the disciplines of artificial intelligence research and empirical methods of psychology. Fuzzy logic principles, grounded in artificial intelligence from whence fuzzy logic arose and continues to be applied, are embedded in the underlying design of the method. The processes of *Fuzzy IDEAS* are related to empirical psychology and empirical musicology. Although psychologists are generally concerned with testing the validity of statements for human subjects that input *X* correlates to *Y* action outcome, the method of *Fuzzy IDEAS* has been set out clearly, so that the collection and analysis of subjective information about listener responses can be replicated by other researchers. Further, psychologists do not yet necessarily understand or enquire into the actual mechanisms by which this comes about, even though there are

¹ Typically, empirical studies are grounded in emotion, despite acknowledging the existence of other ideas that might inform the composition of music. As discussed in Chapter 2 psychologists have been researching the overlaps between music and emotion with limited experimental data that is often not related to real world listening situations of complete pieces of music. It is possible that *Fuzzy IDEAS* could contribute to their work by more extended applications to more music and more people, while being able to incorporate more ideas than simply emotion.

theories on biological adaptation and neurological studies of the brain². More importantly, as described previously, neither artificial intelligence nor psychology enter the domain of imagination and ideas. Cognition is an interpretive activity (Moore, 1990:4), rather than simply the mental registering of sounds and their intrinsic aural qualities. These are significant issues about the realism of psycho-acoustic research, some of which may be dealt with through using *Fuzzy IDEAS* as an empirical research method.

Although *Fuzzy IDEAS* does not attempt to understand or imitate the biological connections between aural perceptions and listener response, it does investigate how observed technical qualities and cognitive responses to the unfolding sound of the music contribute to an ideational response in a single listener. This thesis has been confined to outlining the theoretical and conceptual reasons for the methodology employed by *Fuzzy IDEAS*. This thesis has been concerned with developing a proof of concept, not testing it broadly in the field. In particular, great care has been taken to ensure that the method is clearly set out so that other researchers can replicate the demonstration analyses, or design their own to contribute to further development of *Fuzzy IDEAS*.

The results produced in each of the demonstration analyses and the evaluation clearly suggest that *Fuzzy IDEAS* can be useful in distinguishing pieces of music and listeners. *Fuzzy IDEAS* could be used in more extensive testing in empirical research into modelling generalised listener response to realistic music stimuli. *Fuzzy IDEAS* at present is relatively efficient in that, like other fuzzy logic applications, it works with single expert input to develop the system, along with iterative fine-tuning, rather than extensive number crunching and large-scale empirical databases.

Fuzzy IDEAS has been developed through dialectical interaction between the practical application in the demonstration analyses and the theoretical considerations the method is designed to incorporate. There is potential for further refinement of this novel method by applying fuzzy logic to capturing and representing the time domain measurements to enable the visual representation of

² The overview of psychological investigations into brain mechanisms for emotional responses to music by Juslin and Ljindstrom (2010) discussed previously in Chapter 2 is a useful exception.

elapsed time to represent actual subjective experience of the passing of time³. However, testing to see what terminology listeners broadly use to describe sound events and their cognitive responses could provide a useful addition to the existing model. Although the worked examples which demonstrate *Fuzzy IDEAS* are all based on avant-garde music, it would also be interesting to test *Fuzzy IDEAS* on more conventional score-based tonal music. Other work could investigate the generality of *Fuzzy IDEAS* in statistical quantitative research to test the generality of specific results by using the same music on other listeners. Further quantitative research might establish *Fuzzy IDEAS* as a useful tool for population-based research by psychologists and investigators into general listener responses. *Fuzzy IDEAS*, as it stands, provides insight into how an individual listener engages with the materials of the music and make sense of their experience of a piece of avant-garde music. *Fuzzy IDEAS* could be used in empirical testing to develop a comprehensive predictive theory about the extent to which factors extrinsic to the sound of the music, such as title, marketing and presentation context, contribute to a listener's engagement with the music. As Pitts observes, there is very little research into these factors for art music especially when compared with the research into popular music (Pitts, 2005:267). Empirical research could also investigate how these factors outside the sound of the music impact on the 'sense-making' experience for listeners in general. These experiments are all conceived as using *Fuzzy IDEAS* as a research method for undertaking well designed empirical experiments designed to establish general conclusions about listeners and music.

However, looking to the future of music analysis and composition more broadly, *Fuzzy IDEAS* has potential for increasing audience support for new music. Appendix E. Avant-garde Music in the 21st Century Australian Marketplace shows that avant-garde music is generally not well supported by the 21st century market-driven economy. This does not mean that the music does not have value and cannot make sense to diverse listeners if they have appropriate and useful tools with which to approach the listening experience. There are many potential uses of *Fuzzy IDEAS*, as it currently stands, to encourage audience engagement with avant-garde music during listening and in terms of attending concerts.

³ This is clearly another research topic, but we know from experience that the passing of time in our minds and bodies is different from the passing of time according to the clock.

Fuzzy IDEAS could be used to attract larger audiences to concerts through possible extensions into new modes of data-capture which might further enhance audience engagement with avant-garde music, as well as provide new tools for experimental research on listener responses to this and other Western art music. For instance, annotations could be made in real time in digital form through an application which allows comments to be typed while the music unfolds, such as exists in *Soundcloud* (SoundCloud). However, *Soundcloud* works only with pre-recorded audio files on an internet site. What we need is a facility to make annotations when listening to live music. Future testing of *Fuzzy IDEAS* on a variety of listeners and with a variety of music could establish ways of using *Fuzzy IDEAS* to achieve these goals. Additionally, *Fuzzy IDEAS* can be developed as a digital research method to provide an automated means of mapping and aggregating audience responses in real time. This future development could provide immediate information on linkages between technical aspects of the music and audience reaction.

A more obscure development, and testing, of *Fuzzy IDEAS* is the reconstruction of music from the fuzzy representations. The visual representations are a form of compressed information with added tags. The compression occurs through auditory perceptual processes and technical issues of documenting observations in real time. The tags are the reflective events and partially indeterminate events. Data compression is the elimination of redundancy, i.e. removing those parts of the data stream which are not important to its meaning (Cope, 2008:51). Data compression can reveal higher levels of information not easily noticed in large masses of data. So data compression in itself is not necessarily a bad thing, and obviously occurs in music analysis as it seeks to show specific relationships at particular levels more clearly (Walser, 2003:25). In the digital world, validity of a compression method is judged on whether the original data stream can be restored, in this case whether the actual music can be reconstructed (Cope, 2008:57). The compression that occurs through *Fuzzy IDEAS* means many different pieces of music can be reconstructed from this data if each piece contains the qualities of the noted moments at those time points and in the context set up by the title. Yet it is also possible that each piece could produce similar sense-making responses across a broad range of listeners. This would be interesting to test in future work. In the meantime, there are more direct and immediate applications of *Fuzzy IDEAS*.

7.1 Composition Pedagogy

Fuzzy IDEAS can contribute to composition pedagogy through the qualitative observations on the music collected during listening and, in its later stages, by providing an in-depth analysis of the perceived technical attributes of the music and their impact on the listening experience. This further analysis may provide insight into how well the music projects and supports the ideas the composer may have been working to express through this music.

The activities of composition and listening each start with a ‘Musical Thought’ (Moore, 1990:4). This, as Moore elaborates, is the beginning of a process that includes perception and cognition (defined as interpretative mechanisms), sensation and imagination. Sensory information is a basic building block of communication, while art portrays imagination (Moore, 1990:4). In fact, “...the artist aims to express what has already been imagined” (Moore, 1990:8). Sound is the manifestation of music that can be objectively measured. Because music is produced for humans we must also deal with the perceptual qualities of sound. “Musical imagination tends to work in terms of desired interpretations that a musician wishes to impart to the listener on a cognitive level...it is the responsibility of the musician to understand the mapping of these [physical] properties [of sound] through the perceptual and cognitive processes of the listener” (Moore, 1990:23). The difference between composing computer music and acoustic music primarily comes down to the fact that computers enable precise, repeatable experimentation with sound, while requiring a strong interdisciplinary approach combining art, science and technology (Moore, 1990:4).

“The study of emotion and affect is of burning importance in the humanities, as well as the social and biological sciences. Philosophers, psychologists, and scientists talk about musical emotion; it is time now for music analysis to join the conversation.” (Spitzer, 2009:3). The contemporary paradigm of music scholarship does not have the tools for talking and writing about responses to music as a lived experience (Juslin and Sloboda, 2001:5). Other issues arise through music education, because mostly there is no explicit teaching of emotional communication skills to composers and improvisers, or to performers. This might be the result of the deficit in valid research into understanding how communication of emotions might work (Juslin

and Sloboda, 2010:939). Consequently, discussing the expression of ideas as a branch of music theory and compositional pedagogy is nearly impossible, except in casual conversation.

“The very act of teaching composition is a tacit acknowledgement that you can not only diagnose a distinction between “idea” and “utterance” but that you can also remedy the situation. A good composition teacher does not merely re-compose his students’ work. He helps them to search for its truer expression. It is his chief function to help his students to keep reformulating the “utterance” until they have captured the “idea” (citation from Alan Walker (1966) *An Anatomy of Musical Criticism*, pp.72-73, in Gann, 2011). Although audience response is individually subjective to a degree, listening still needs to be considered to maximise the possibility of making the composer’s ideas clear to a diverse audience. Lindstrom, Camurri et al. empirical research shows that designing a piece of music so it makes sense to the audience is an important role of the composer in engendering a positive regard, whether emotional or ideational, for the music (Lindstrom, Camurri et al., 2005:82-83)⁴. Compositional pedagogy does not address the question of how listeners make sense of music. Rather teachers, such as Kaschub and Smith (2009:5), appear to rely on the composer’s innate abilities to absorb this information as they observe listeners responding to music⁵. *Fuzzy IDEAS* can be used to determine how compositional decisions may suggest ideas to diverse listeners. This may enable composers to take the audience along with them, to make sense of their music, to assist listeners to value the music the composers design.

Signposting the specific ideas in the music begins with the text of the title. During the 20th century, new ways of composing music have brought new sounds and new forms. The sounds produced by acoustic instruments are relatively stable and known, while “... programming allows indefinite variations and unlimited flexibility. The process thus promises access to an unbound world of sonic material, amenable to a huge range of transformations” (Risset, 1988:3). This new world of digital

⁴ Milicevic’s benchmark for compositional success is more confined to requiring that music engenders only positive emotional response (Milicevic, 2002:127).

⁵ Indeed contemporary pedagogical practice suggests that engendering audience responses is not the primary purpose of composing music, but rather the significance of learning compositional craft lies in its development of self-awareness in the composer (Kaschub and Smith, 2009:85).

transformation has not been accompanied by new terminology to help listeners predict or understand what they are about to hear. Additionally, there seems to have been increasing pressure for composers to be new and original, to do things their own way, which may imply that it is not possible to apply generic descriptions to individual pieces of music. Yet, most inexperienced listeners use the title to identify sounds and interpret what the music might be about (Weale, 2006:194). There is still a need for 21st century composers to select their titles to communicate something of the sound world that will be experienced when listening.

Avant-garde composers choose titles, which may or may not be helpful. For instance, the titles of two sets of music by Schoenberg, *Three Satires for Mixed Chorus* op 28 and *Four Pieces for Mixed Chorus* op 27, indicate music which may be different in character, the latter being 'serious' rather than 'satirical' (Deliege, 1976:30). By contrast, the title *Eclat* was deliberately chosen because it has multiple meanings, which refer to the form, its content and its 'poetic expression' (Boulez in Deliege, 1976:87). Similarly, *Lady Neil's Dumpe* "...takes its title from a number of sources...the earliest known English keyboard composition...a Renaissance dance...jazz tradition...a storage location for files in a computer memory" (Bresnick, 1987). Neither of these titles clearly prepare the listener for the sound world of the work, although they do signal that ambiguity is likely to be a feature of the music.

Computer music works are typically distinguished by the composer on the basis of the technicalities of computer programming, and the specific technologies of sound production employed. Abstract titles can be an inadequate means of framing the listening experience as most people are unable to interpret the actual meaning of the title and so are unable to use the title as means of orienting their listening (Weale, 2006:194 note 6). For example, Scott A. Wyatt has titled his work *Still Hidden Laughs: for Synclavier and Yamaha Systems* (Wyatt, 1988). This title suggests very little about the nature of the music. A sonic concept encapsulated in a title provides a clear guide to prepare the listener for the ensuing work, by indicating where to focus her attention. Although there are no terms equivalent to the historical formalities for giving titles to avant-garde music in general, it is still important to orient the listener through providing a useful title. Titles provide specific indications or implications about the purpose for which this music is composed and hence the ideas, as a frame within which the music may be heard.

This goes beyond Meyer's requirement that the audience be familiar with the style and form of the work they are about to hear, so there is a "...common universe of discourse in art: a common set of gestures known to the group, and a common understanding of the meaning of those gestures" (Meyer, 1956:42). Listeners may approach unusual and unfamiliar music with a generosity of spirit that knows that "All behaviour makes sense from the actor's perspective or else they would not do it." (Langer, 2005:45). However, a useful title provides a means for listeners to begin with some initial insight into the music. The audience may then find it easier to make sense of what they hear and appreciate the composer's efforts.

Historically, there have been a variety of explanations about how music works with emotion. In the 17th and 18th centuries, a piece of music was seen to be similar to public-speaking, using similar rhetorical principles, typically discussed and known as the 'doctrine of affections' (McLary, 1991:20). These principles insisted that emotional meanings and signification were determined by the instrumentation, specific qualities of the sound events, and the form of the music. Recent suggestions cover a range of similar mechanisms. For instance, a practiced listener may find meaning in abstract music by experiencing an emotional response to disruption of patterns in the music (Meyer, 1956:30-31). Alternatively, some psychologists propose that the multiplicity and complexity of real life emotional processes are systematically represented by music (Juslin and Sloboda, 2001:13). Others see the similarities between vocal expression and music as the means by which music can express emotion (Juslin and Laukka, 2003). *Fuzzy IDEAS* may be useful in revealing to composers which aspects of their music are important to listeners and their responses, in a wholistic multi-dimensional manner.

Music theory does not even attempt to go to 'sense-making', hence compositional pedagogy does not go there either. Music theory is merely a lexicon of terms, or a grammar of particular constructions, as exemplified by the Music Theory syllabus for the Australian Music Examinations Board (2002:39-44). Music theory, in general, sets out the basic principles that govern music, while music analysis is an account of how those principles are applied in practice in a specific body of work (Cope, 2008:2). Music analysis has attempted to put the study of composition on a scientific footing. The science method based on repeatable, so-called 'objective' experiments, is designed to prove/test/establish a theory. Scientific theories are

constructed from evidence through empirical observation to predict future action of the system under examination. Music analysis and theory in general, except perhaps the baroque ‘doctrine of affections’ does not attempt to, nor is able to, be predictive about audience responses to technical details in the music. The value *Fuzzy IDEAS* provides is through its explanatory capacity. This new approach to addressing the impacts of compositional decisions on the listening experience could be useful as a tool for teaching composition. *Fuzzy IDEAS* may enable the articulation of the unspoken in musicology, that composers somehow inarticulately know how to put expression into music, and that somehow listeners know how to get it out again. Potentially, these tools and insights could be applied to compositional pedagogy. Recognising that “...listeners usually judge expression of composed music as realised in performance, there is a confounding of the properties of the composed structure and the properties of the performance...” (Gabrielsson and Lindstrom, 2010:368), *Fuzzy IDEAS* also has the potential to provide new input towards a predictive theory of music ‘affect’.

7.2 Audience Development

Fuzzy IDEAS has a number of attributes that could make it useful for audience development. The value of *Fuzzy IDEAS* lies in its listener-orientation and in the method of visually representing a listener’s individual experience to provide useful and transparent tools to address the problem of listening to unfamiliar and unusual music.

Generating the qualitative listening observations may require active listening, but making sense of unfamiliar music is not necessarily difficult, nor need much background preparation. An ‘uneducated’ listener is in the position of making sense of music with which they are unfamiliar. An important, yet innovative, premise of *Fuzzy IDEAS* is that listeners do not have to be familiar with the style or genre of the music, but that the aural experience of the music itself may suggest ideas regarding the purpose of the music. The goal is to take the music on its own merits, along with its title, letting the sound of the music be the means of suggesting ideas, to be part of a ‘democratic listening experience’, which is not reliant on background information about the composer, nor prior education in style, nor reading of program notes.

The auto-ethnographic process embedded in the first three stages⁶ of *Fuzzy IDEAS* helps a listener engage more fully with a specific piece of music for several reasons. Firstly, it causes the listener to pause before listening and think about the implications of the title and any other available information on how the music is going to make sense. Secondly, it focusses the listener's attention on the sound of the music. Thirdly, it provides an opportunity to articulate any and many cognitive responses to what is happening in the sound of the music - including joy in the unexpected and boredom with repetition - so that personal reactions are clearly valued as part of the music equation. Equally, *Fuzzy IDEAS* values what is heard rather than making negative value judgements on listeners for missing details of the music. Listeners can write down what they hear in their own way, as there is no proper or correct language to describe the content of the music⁷.

As explained in Appendix E. Avant-garde Music in the 21st Century Australian Marketplace, the need for increasing public support of avant-garde music is evident. Much of the difficulty originates in the unprecedented availability of diverse music for 21st century audiences who no longer need to listen to music composed by their contemporaries, especially music which challenges established expectations of art music and its enjoyment. Some of the difficulty resides in the experience of any unfamiliar and unusual music. Documented contemporary reception of Chopin and Beethoven's music shows that newly composed music can be difficult for any audience to understand. However, because it deliberately confronts long-standing conventions, avant-garde music produces extra challenges. However, it is possible for audiences to appreciate and value avant-garde music if they can make sense of their experience of the sound of the music. The question then becomes a matter of assisting diverse listeners to make sense of the stream of sounds that constitute unfamiliar and unusual music.

Sense-making is a democratic approach to listening that foregrounds the experience of the music, rather than the compositional techniques or insider knowledge of

⁶ See Chapter 4. Stage 1. Documenting Pre-Listening Pre-Conceptions, Stage 2. The Qualitative Listening Observations and Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience (pp. 145-149).

⁷ It is clear that my choice of language is influenced by my music training but, even so, there have been some extraordinary moments in each piece where technical music jargon could not describe simply the impact of the particular quality of specific sound events.

trained musicians. Lott documents mid-19th century critical perception in the USA that diverse audiences without musical training would not understand performances of the newly emerging canon of masterworks of dead composers (Lott, 2003:294). Nonetheless, Lott's research also shows that contemporary critics noted the continual enthusiasm, judging by the strength of the applause across diverse audiences, for some individual pieces of this repertoire (Lott, 2003:294). Pitts' evaluation of audience members and their sense of belonging to an art music culture concludes that "Individual experience is at the heart of meaningful listening, and recognition of the perspectives of audience members has much to contribute to practical music-making and to a broader understanding of musical life in contemporary culture" (Pitts, 2005:269). Achieving larger and more diverse audiences means addressing these issues.

It is already clear that there is little audience engagement with avant-garde music and that without positive recommendations to encourage new listeners to new art music, avant-garde music is consigned to relative ignominy. One solution is proposed by Milicevic (1998c; 2002) and Whalley (2000a), who both demand that contemporary avant-garde composers should use only established forms and paradigms of emotional narratives guaranteed to produce positive emotions in listeners. This demand to compose in the same old styles, which may satisfy audience demands for beauty, transcendence, and entertainment, would defeat the purpose of avant-garde music as practice-led research into new directions of music.

Supporting listeners to appreciate avant-garde music and its cultural value, could be assisted by a strategy which encourages 'democratic listening' to unfamiliar music by diverse audiences. As Becker argues, audience reception can be important in determining what is accepted as 'music' (Becker, 2008:214). Lesaffre, De Voogdt et al., have established that listener responses to unfamiliar music are affected by how open-minded individual listeners are to a variety of music (Lesaffre, De Voogdt et al., 2008:699). As discussed in Chapter 1 (see Section 1.3. The Challenges of Making Sense of Avant-Garde Music) there are several preconceptions and problems encountered by listeners when experiencing avant-garde music. Consequently, helping diverse listeners bring an open-minded approach to music with which they are unfamiliar may result in broader awareness that avant-garde music can make

sense and can provide positive listening experiences, thus expanding audience sizes and improved financial support for the production of avant-garde music.

The problem of broadening acceptance that new music is important and valuable requires a strategy that encourages listening to avant-garde music as a meaningful activity rather than a waste of precious resources; to enjoy the experience of listening to avant-garde music on its own terms for what that music has to offer. Conceiving unusual and unfamiliar sound streams as music requires that this particular cognitive activity be perceived as relevant and valuable to the listener. The perceptual shift from awareness of sounds to thinking of music requires a listener to imbue these streams of sound with ideational responses, to find some way of making sense of their experience of that music.

Fuzzy IDEAS can easily be adapted into pedagogical strategies for school students with long-term benefits in audience development thereby increasing the appreciation of and support for established and new art music. *Fuzzy IDEAS* can also make a new contribution to audience development as a tool for building music appreciation skills across a broad base of adult listeners. There appear to be straight-forward extensions of *Fuzzy IDEAS* into music appreciation curriculum for children and adults, and into the development of music composition pedagogy.

Fuzzy IDEAS is not only useful for teaching music appreciation, but is also a potential tool for increasing contemporary audience engagement with avant-garde music in real time, while they are listening. *Fuzzy IDEAS* provides a novel means of focussing the audience on qualities of the music and the effects of those technical features.

The proof of concept presented in this thesis, that fuzzy logic provides an excellent platform for the visual representation of a listener's experience, provides new opportunities for audience development through building new technological applications to help build a sense of community among listeners, and between audience and performers. At present, concert-hall audiences are expected to passively listen and absorb music. Lindstrom, Camurri et al, have demonstrated that actively and directly involving listeners in the artistic control of the sonic qualities of the music being performed is significant in producing a positive audience response to new and unusual music content and modes of presentation (Lindstrom, Camurri

et al., 2005:82). Similarly, *Fuzzy IDEAS* may already provide some sense of active participation in the music to those who would otherwise listen passively⁸.

Because it requires listener activity to document the experience of the music, *Fuzzy IDEAS* may be useful in building audience reception in real time. The actual technology employed in the initial stages of *Fuzzy IDEAS* is accessible and open to general use by listeners for documenting an open-ended range of technical and ideational responses as they occur in real time, as well as open-ended responses immediately after listening. This may be sufficient to encourage diverse listeners to engage with music sufficiently to immediately appreciate some aspects of that music during the listening experience.

Being sociable and part of a community is an important aspect of concert attendance. Pitts' empirical research establishes that those who attend art music concerts enjoy the music and being sociable with like-minded people who may be strangers rather than friends, but nonetheless have similar interests in discussing the music (Pitts, 2005:269). Unfortunately, as Pitts explains, concert hall conventions are at odds with 21st century life so the whole concert situation presents barriers to first or repeat outings for many people, except for the most habitual attendees. She argues young people want to use their leisure time for more strongly social activities than are typical at an art music concert. There is a clear perception that the production of art music is a solitary activity because the performers don't interact with each other, let alone the audience. Concert hall convention also ensures that reception is a solitary activity, as an audience shows no collective activity except clapping (Pitts, 2005:258). There is no noise, no dancing, no response to the music while it unfolds in real time.

There are technical aspects of *Fuzzy IDEAS* that can be developed through social networking tools for polling the audience as the music unfolds. Turning *Fuzzy IDEAS* into an automated form appears to be a relatively straightforward, if time-consuming, development as the method has already been codified during my research for this thesis. This codification is clearly evident in the demonstration

⁸ This does not mean to imply that listening is necessarily a passive activity where the listener is not thoughtfully engaged with the music, but rather to make the distinction between being involved in the performance and being a silent recipient of what is presented.

analyses in Appendices A-D. New technological tools built on *Fuzzy IDEAS* could research the characteristics of audiences for art music of many different genres by mining audience-wide data responses for meta-patterns. This type of information could include data on how many respond, and with what kinds of responses, to specific music and across genres, performers and concert venues.

These future developments may also provide a stronger sense of participation in the experience of the music and a sense of belonging to a specific social group. Pitts reports that there has been limited research into the social aspects of being in the audience at art music concerts, while theatre audiences have been very well studied (Pitts, 2005:269). This new type of collective experience of audience participation may induce diverse listeners to attend avant-garde music concerts. By turning *Fuzzy IDEAS* into applications for wireless handheld devices to use during real-time listening, such as real-time polling of listener response, auto-ethnography becomes a shared experience.

7.3 Marketing Tools

Suggesting that composers communicate more effectively is only part of the solution. As noted separately by Halpern and then Weale, sense making could be impacted by marketing tools which direct listeners' focus and attention for specific music (Halpern, 1992; Weale, 2006). As Halpern observes, current marketing of classical music which requires insider knowledge of classical concert music in order for the marketing to make any sense, removes the possibility of 'uneducated' listening, with consequent impacts on audience reception for that music (Halpern, 1992:45). Avant-garde music is even more likely to suffer from poor marketing strategies. Possibly the marketing of this music may not sufficiently orient the listener with respect to what they are about to hear. Marketing of avant-garde music in general could be improved by providing information on the technology and the way it works. Lindstrom, Camurri et al. have shown that making this type of information immediately available before listening has some positive effects on audience response (Lindstrom, Camurri et al., 2005:82). Marketing avant-garde music from the listener's perspective means that the particular features of the music which might attract listeners need to be identified and used to promote the concerts

(Weale, 2006:198). The analysis of Reflective Events may be useful for developing new marketing strategies. The later stages of *Fuzzy IDEAS* still need an analyst to create the visual representations of the listening experience, and then to interpret the analytical results into possible meta-ideas that inform the composition of the music. However, these stages, as well as the outcome of the initial listening observations, may provide useful insights into those aspects of the music that attract particular audience responses. These can then be used in marketing strategies for particular music.

Additional marketing opportunities arise through the further development of *Fuzzy IDEAS* to enable real-time interactivity, social networking and playing with new technology. *Fuzzy IDEAS* could be developed for use as part of a marketing strategy to entice tech-savvy audiences. For instance, new technical extensions of *Fuzzy IDEAS* could be used in the local concerts to provide a massed visual representation of audience responses. These may provide an additional layer of interest to the audience or, with some additional tweaking, could be applied to map geo-location of responses on a global scale.

In conclusion, these potential developments point to the value of the research reported in this thesis. My research using fuzzy logic principles in the visual representation of a personal listening experience demonstrates it is possible to develop a transportable method of making sense of music which openly acknowledges subjectivity and explicitly incorporates the time domain. As Kreković, Pošćić, and Petrinović, (2016) have recently confirmed fuzzy logic provides a solid basis for subjective human interaction with machine algorithms. Moreover, their results show it is possible to fuzzify data across multiple features of a single attribute (sound type) to create a generic, transportable, yet transparently comprehensible, human/machine interface for synthesising digital sounds across a variety of commercially available software. This research focussed on one attribute of sound supports my own claim that by simultaneously addressing multiple attributes of the subjective experience of listening to music my new method can be used to make sense of music composed using any materials, techniques and forms. Further, although my thesis is concerned to establish the proof of concept that fuzzy logic is useful in capturing that experience in visual form, so that *Fuzzy IDEAS* has enormous potential for further development in automated music analysis.

Concluding Remarks on the Value of *Fuzzy IDEAS*

This thesis touches on a broad range of ideas within musicology. Indeed, many of the basic questions addressed by my research are not new, yet comprehensive answers prove elusive. Current approaches to music analysis use a variety of procedures to address different genres of music, as well as ways of dealing with the inherently inescapable subjectivity of analytical decisions, and the complex problems associated with making sense of the intangible unfolding aural process we know as music. I have addressed this challenging backdrop by developing a way to visually represent the multi-dimensional subjective nature of a single experience of listening. I have argued that fuzzy logic provides useful and informative principles for visually representing the subjectively-experienced characteristics of music during listening. The application of fuzzy logic principles enables analysis to bypass music notation, yet be systematic, extremely flexible and adaptable.

My research demonstrates that visual representations which openly acknowledge the subjectivity of individual listening responses and explicitly incorporate the time domain can be useful tools for identifying the technical and formal aspects of a piece of music which generate ideas that make sense of the sound of that piece of music to that listener. The visual representations allow the same process to be used for different music and for different listeners, while being sufficiently flexible and adaptable to capture information from each of these diverse experiences. The data collection methods and the resulting visual representations have strong ecological resemblance to realistic concert-style listening to a complete piece of music. Successfully capturing the subjective experience of listening to music provides us with new information which feeds into compositional pedagogy, music education and appreciation, and new ways of engaging listeners with avant-garde music.

In the late 20th century, computer scientists developed fuzzy logic to explicitly incorporate human subjectivity when solving problems involving imprecision and uncertainty. I have used fuzzy logic to represent the qualitative listening observations because fuzzy logic permits the use of incomplete data and the incorporation of subjective response as well as technical information. Further, information can be described in natural language, while fuzzy logic can capture

complex systems in reasonably transparent detail, and is particularly useful for describing vague and uncertain parameters.

The application of fuzzy logic to music analysis has been previously suggested by two European musicologists, Heister (2012a) and Ciocan (cited in Rădulescu, 2012), and has been implemented by several computer scientists in the automated analysis of score-based instrumental music based on a few predetermined attributes (Bresin, De Poli et al., 1995; Cope, 2005; Friberg, 2006; Arcos, 2012; Arcos, Guaus et al., 2013). The work presented in this thesis is the first practical application of fuzzy logic to classify information arising from a single human experience of listening to an entire piece of music which potentially includes all attributes of the sound of the music.

Converting qualitative listening observations into fuzzified data provides a visual representation of that individual listening experience. This visually representation of an individual experience of listening provides tangible evidence for abductive conclusions about how an intangible aural experience, such as music makes sense. Visual representations are also useful because they present information in a format which highlights significant aspects of the data in a reasonably comprehensible manner. Explaining complex data and results in text can be lengthy and difficult to follow, as recognised by the epithet “A picture is worth a thousand words”.

The general principles that inform *Fuzzy IDEAS* in turn affect the methodology for collecting the listening observations. Because *Fuzzy IDEAS* is designed to be inclusive, transparent, systematic and transferable I have explained the new method using my own experience of listening to four pieces of avant-garde art music. Further, my evaluation on three other listeners who had varied levels of music training and liking for avant-garde music, suggests that *Fuzzy IDEAS* can be a constructive and open-ended method for making sense of music composed using any materials, techniques and forms. These are significant reasons for using fuzzy logic and developing a visual representation of the music as experienced in a concert style listening situation.

My evaluation suggests that *Fuzzy IDEAS* can be successfully implemented using information from listeners with various levels of music training. As Choi observes,

different people will use different terms to describe the same object because they will have different interests, concerns, knowledge or skills (Choi, 2002:306). *Fuzzy IDEAS* describes the listening experience as it unfolds, so that each piece of music can be taken on its own terms. There is no assumption that the listener is educated, or knowledgeable about that specific form or genre of music. Given the ubiquity of music in everyday life in 21st Western culture, every person will have some experience in listening to music. One of the key features of the information collection method in *Fuzzy IDEAS* is its meaningful comprehensibility to those who are not musical initiates.

The collection methods were designed to capture the listening observations available in concert style while listening to a new piece of avant-garde music. I have shown that *Fuzzy IDEAS* can capture both technical context and the sense-making decisions of a listener as they experience the music. Importantly, the subjectivity of response and the passing of time were explicitly included as primary attributes of the lived experience of actively listening to a piece of avant-garde music. The sense-making decisions are entirely free-flowing “...governed by... a sense of the situation in which you are located at that time.” (Langer, 2005:102). *Fuzzy IDEAS* provides a framework to explore an individual listener’s decision-making about ideas in the music through a mindful approach to the process of making sense of the experience of listening. *Fuzzy IDEAS* discovers the perceptible organising principles for a piece of music from each listener’s perspective.

Drawing conclusions about possible, plausible ideas the composer may be expressing through a piece of music is an abductive process, whereby each listener formulates the best hypothesis to explain what they perceive about the music at different stages during the listening experience. *Fuzzy IDEAS* starts from the premise that “We begin any form of creative engagement uncertain of what to do next, what options to consider, or how the option we select will feel to us...” (Langer, 2005:225). The new method assumes that ideas generated by a listener in response to the music are context-sensitive, arising and refined as new aural information becomes available. The specification of *Fuzzy IDEAS* permits variation in classification of information from one piece of music to another. The final stage, which may be either conducted by an analyst-listener themselves, or by an

investigator using fuzzified data from one or more test subjects, is where the analyst draws their final abductive conclusions based on all the information available.

Fuzzy IDEAS has been designed to include all possible ideas, not just emotion, and to be general across all possible expressive devices. Although the conversion process from qualitative listening observations to fuzzified data is specified using a physical sound object as a metaphor for music, the actual information from each listener is determined by the pragmatics of their decisions about how best to describe and document their actual experience of listening. The types of information and their classification into attributes and feature sets within each analysis are thus neither completely predetermined, nor randomly selected, hence avoiding the psychological effect of categories being meaningless to any individual listener (Langer, 2005:226). However, as Choi observes, human experts provide highly useful classification of information because their perceptions of the importance and relevance of particular information is determined by the context (Choi, 2002:307). Qualitative listening observations therefore may include time points, physical aspects of the sound, and any associated 'cognitive events' associated with self-awareness of perception.

Fuzzy IDEAS incorporates the potential range and complexity of sonic variables with which a composer works to produce music, while integrating the subjective reality of a personal listening experience. This new method uses a single idiosyncratic experience of close listening to suggest a plausible idea being expressed by the composer through this music. This practical implementation of fuzzy logic within *Fuzzy IDEAS* translates personal cognitive responses and momentary technical perceptions of the music into a detailed yet transparently meaningful visual display, which is relatively straightforward, although potentially time-consuming to analyse in detail. The work flow in *Fuzzy IDEAS* moves from the pre-listening preparation through contemplation of the title of the music; to gathering and documenting the qualitative listening observations; converting these qualitative listening observations into fuzzified data, which are then mapped into a detailed set of visual representations of a personal listening experience; conducting visual analysis on these charts; then drawing all these pieces of information together to form conclusions about possible ideas being projected through this music to this listener.

Results from my demonstration analyses and the evaluation suggest that using sound as a metaphor for music is a useful place to start the classification process and that listeners consciously attended to the basic attributes at times. However, the degree to which each of the basic attributes of sound were highlighted by each listener remains individual. Overall, reporting of basic technical attributes was much less frequent than I had anticipated, while reporting of Reflective Events was consistently high, particularly among the respondents in the evaluation. In this way, my research identifies that sound is a better metaphor for music than the score, because score analysis is not able to identify or work with these cognitive events.

In every example, the qualitative listening observations from each listener enabled abductive conclusions which progressively used the incremental step by step analysis of technical and cognitive evidence to make sense of the music. Each idea which makes sense of that individual experience of listening is not conceived to be generalisable among listeners. The purpose of *Fuzzy IDEAS* and the visual representations is to work through the qualitative listening observations to provide evidence to support an idea which makes sense of that experience.

It could be an important step to begin testing across a larger number of listening subjects to investigate the possibilities for generalisable results, but my research to this point was not seeking generalisable results across a broad range of listeners. Rather, *Fuzzy IDEAS* is a consistent method which could be applied to different listeners, and different music, to explore individual subjectivity in detail, each on its own individual terms. My evaluation shows that my method captures each subjective experience quite differently, retaining its individual character.

I have shown that using fuzzy logic enables the systematic production of visual representations of the lived experience of music that provide evidence for interpretation. The visual representations are produced and analysed in a process consistent across listeners and music, although each experience is analysed on its own terms.

Fuzzy IDEAS was not deliberately designed to help diverse listeners appreciate the music, but rather to investigate connections between observed technicalities, and cognitive events in response to the music, and how these can be used to make sense

of the music. However, I have shown that this new analytical method has potential to contribute to compositional pedagogy by enabling composers to actively engage with listener responses to their music because *Fuzzy IDEAS* provides a method for documenting and analysing detailed feedback on the communicative aspects of a piece of music. The method in its entirety can be time-consuming: because as expected, the types of responses and the qualities of the music described by each listener varied considerably. In its present format, the manual coding of the responses into fuzzy logic entities for each listener and generation of the visual representations takes from three to eight hours. Another eight hours of description and analysis of the visual representations is required to draw out the abductive conclusions regarding ideas projected by the fuzzified data. It is not a fast process, but neither is conventional score based music analysis. However, there is real potential for automation of at least some steps of *Fuzzy IDEAS*, and this remains an important subject for a future investigation.

Fuzzy IDEAS is also educative. Even though the impact and implications of the thought revolution of the 20th century remain full of possibilities still being explored by composers in 21st century Australia, there is little desire by diverse listeners for the experience of new music; hence, there is little financial support for the composition of 'new' music, within or outside the academy. A novel contribution towards solving this problem is *Fuzzy IDEAS*, which can assist diverse listeners engage with music containing unusual sounds, forms and presentation methods. The practical demonstrations of *Fuzzy IDEAS* show that the process of collecting open-ended responses during listening helped myself and all test subjects to actively focus on the music. An unexpected result was that collecting the qualitative listening observations improved all participant's appreciation of the music at the time of listening, while they welcomed the opportunity to express their positive and negative responses to the music in detail. All listeners in the evaluation commented on the positive impacts of the data collection method required by *Fuzzy IDEAS*, and reported their participation had enhanced their experience of the test music.

In conclusion, the original contribution to knowledge made by *Fuzzy IDEAS* is, through investigating the intersections between analysis of compositional design and personal listener response, provision of a method to address the difficult topic of making sense of any type of avant-garde music.

The most important contribution is the development of visual representations of the subjective experience of music in a way that is transferable and repeatable between users and pieces of avant-garde music. The evidence from my own listening and results of the evaluation questions regarding the utility of the data collection method indicates that *Fuzzy IDEAS* is a useful tool for musicologists to analyse any type of avant-garde music, composers to engage with listeners, and listeners to engage with avant-garde music. The way I have applied fuzzy logic principles in this new method provides material for potential applications across a number of diverse research areas, beyond music appreciation.

Fuzzy IDEAS has promise for new technological applications to provide additional modes of listener engagement during concerts. Potential future work could include testing *Fuzzy IDEAS* on more listeners and analysts, using both avant-garde and conventional score-based music. *Fuzzy IDEAS* contains the possibility of new data collection strategies into general listener responses for academic research and/or to inform the marketing of Western art music.

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Appendix A. *Fuzzy IDEAS* applied to *Scharlachrote Buchstaben* (Heller, 1984)

Scharlachrote Buchstaben (Heller, 1984) is the music used in this worked example, which demonstrates how *Fuzzy IDEAS* works to discover possible ideas in this music along with the technical aspects of the music, which have stimulated those ideas. This worked example follows each stage of the method set out in Chapters 4 and 5, using my own experience of listening to this music. The first section provides detail on the information collected prior to listening to the music about prior knowledge of the music and the impact of the title as a framework for listening. The second stage, which is not directly documented in the analysis, is the collection of the qualitative listening observations while listening to the music in real time, while the fourth stage provides details of any problems encountered in the collecting the qualitative listening observations, and details the qualitative listening observations collected for each Reflective and Partially Indeterminate Event. The intermediate stages are where the conversion to fuzzy logic entities and the visual representations of the fuzzified data are worked through. The final Stage 9 draws out the ideas implied by analysis of these visual representations, in conjunction with earlier conjectures which emerged in previous Stages.

Stage 1. Documenting Pre-Listening Pre-Conceptions

The purpose is to identify what the listener brings to this particular listening experience. This section documents various aspects of mental preparation for the listening experience which will both affect and inform the actual experience of the music. This includes considering the possibilities suggested by the title for ideas in the music, along with any preconceptions brought to the listening experience through prior knowledge of the composer or the style of music.

The title is in German. It does not contain any words with which I am familiar, since I have very little knowledge of German language. In most concert programs, foreign words would be translated into an English title. Yet this CD cover does not follow the same principle, so based on the methodology of *Fuzzy IDEAS* which requires consideration of the title and any other background information already known by

the listener, but excludes consideration of the program notes, I have no idea to what the title refers. I will be listening to this music without much guidance from the composer, or publisher.

The CD cover does however feature an attribution to a single piano player, so I assume the work is for solo piano. Prior to finding this CD, I was not aware of this composer, nor this composer's work. The CD is produced by a reputable recording company which implies that there is something of interest in this music. The date of the composition, 1984, means that it could be composed in any of a vast range of styles from neo-romantic, through jazz to 20th century avant-garde.

Stage 2. Collecting the Qualitative Listening Observations

I used pencil and paper to document qualitative listening observations about the music or my self-aware subjective responses while the music is playing, along with time points at which those qualitative listening observations were made.

My experience of listening to *Scharlachrote Buchstaben* produced 47 qualitative listening observations over 13'20".

Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience

The documentation of the listening experience concludes with an account of the immediate impact of the complete piece of music as a sense-making experience.

Immediately on listening, it was clear that this piece of music is for solo piano played in a conventional manner.

Despite the constant sound source, Texture is a significant attribute in this music. The capacity to produce several sounds simultaneously on the Piano means it is capable of directly producing a range of complex textures. It is difficult to know whether to describe some parts as Homophonic (i.e. melody and accompaniment) or Polyphonic, in the sense of Baroque style counterpoint. What I can hear are single notes in a clearly separate 'voice', but they are not a traditional melodic motif in the sense that they don't flow directly from one to the next, as they are interspersed

with the material from the other 'voice'. As well, the notes of the opening tone row were of the same duration. However, the single notes are clearly differentiated from the background, and form some kind of group in themselves.

The memorable aspects of the music were the various Textures, ranging from Repeated Single Notes, to Polyphonic sections to Alternating chords. These Textures would emerge, evolve and dissipate, or come to a clear termination. There is also a wide range of Registers employed in this music. The other significant attribute to come to my awareness was Tempo because of the variations in timing of events, and in the overall rate at which events unfolded. There are so many different combinations of attributes and features that finding two events of an identical quality is unusual. The two events which stand out for me as the most similar overall are both Single Notes which Die Away to Silence. There was a distinct possibility that the music was sectional and that some sections never really got off the ground for some reason that was not really clear in the music itself.

What strikes me about this music is there is always something different happening. A significant thing about this work is the speed at which new events and variations of events occurred. The variations occurred in diverse ways. Some features emerged or disappeared out of the music while other features continued. Sometimes a specific type of sound event would be repeated but varied in one attribute. In fact, it became clear that continuous variation was an important aspect of the composition.

Stage 4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations

Any problems arising while collecting the qualitative listening observations are documented here. This stage also provides the detailed qualitative listening observations which capture thoughts, reactions, memories, or images, that rise to conscious awareness in response to the sound of the music. These cognitive events may arise instead of, or as well as, any observations about technical aspects of the sound of the music.

I used a CD player for the listening test. This enabled the use of the digital timer on the CD player to determine the time points of the qualitative listening observations. Using a CD player also meant a fail-safe alert to the end of the music, in the absence of live performance cues, as the next track would eventually begin playing.

Table A.1. *Scharlachrote Buchstaben*: List of Cognitive Events below, provides the listener's qualitative descriptions of cognitive events and any technical observations associated with those thoughts or insights. The precise details of each of these observations are usually quite different from one another. This documentation enables comparison of the qualitative listening observations not only within this particular analysis, but should the experiments be replicated, it enables comparison of whether and how other listeners have described similar events.

This table does not list all the qualitative listening observations for the whole of this listener's experience. Rather this list only details those qualitative listening observations that contain cognitive processing associated with self-awareness of perception, memories and reactions to the sound of the music; moments of focused attention on the music; along with any moments at which the listener has become consciously aware that particular aspects of the sound of this music have stood out. In preparation for the 'fuzzification' of this information during Stage 5, in accordance with the rubric for the method, all documented time points are quantised downwards to the nearest five seconds.

Table A.1. *Scharlachrote Buchstaben*: List of Cognitive Events

Event Number	Time Point	Event Description
E0	0'00"	It is difficult to know whether the series of notes which starts this work is the statement of a tone row, or is a melodic fragment: each note is of equal duration and amplitude, confined to the same register. Although they are not direct repetitions of each other.
E1	1'05"	Arpeggiation with melodic possibility, but it is not clearly one or the other.
E2	1'20"	Arpeggiation, but has clear pedal-tones. Pedal-tones are precise replications of single events at regular time intervals interspersed with other material. These pedal-tones was immediately recognisable.

Event Number	Time Point	Event Description
E4	2'00"	Repeated pedal-tones insistently forced themselves on my attention, but it is not clear when they first appeared in the music.
E6	2'30"	A series of repeated events, similar to the preceding section, with same uncertainty about onset time, but quieter than the previous section.
E8	3'05"	Alternating single notes with chords in a low register insistently forced themselves on my attention, but it is not clear when they first appeared in the music.
E10	3'35"	Melody occurs over the repeating chord alternations established previously.
E14	4'40"	A melody seemed to be emerging from the repeating chords, through being highlighted through accentuation as being separate from the ongoing chords.
E16	5'25"	I have become aware of an unusual event where many different notes are being played nearly simultaneously, rapidly moving from one to another texture in a motion which did not sound random or chaotic, but rather as a swirling directed mass of sound.
E17	6'00"	The material is recognisable as having been previously heard, but is now at a higher Register. However, the onset of this material is unclear.
E18	6'15"	This observation is a time point check through the reflection that despite the previous change in Register, I was still hearing the same material, now for a long time, nearly one minute ago. Yet at this point the music was still aurally interesting, so I was also curious to understand why I was still engaged, which I decided was due to the rapidity of events and the continual variations.
E19	6'25"	The melodic line fades in and out of the accompanying texture, which can only be accompaniment if the melodic line exists.
E22	7'15"	Previous events drawing to a close is suggested by the emergence of both <i>diminuendo</i> and slowing of Tempo.
E24	7'25"	This sounded like the final event of a new section, a quick variation of E21-E22, which never really got off the ground. E24 is a <i>diminuendo</i> leading to silence similar to the preceding section, although the context was different. The material preceding E22 was long and complex, whereas the material preceding E24 was a single note.

Event Number	Time Point	Event Description
E26	7'55"	Sounds like a Beethoven opening gesture, because there is an accompaniment with a very strongly accented melodic motif based on triadic/arpeggiated material. The motif was unified by its accentuation, and by the close juxtaposition of the events. Also the accompanying arpeggiations provided a background against which the accented material could be heard.
E30	8'55"	Uncertainty regarding Homophony or Polyphony as before, but this time the accompaniment is rippling arpeggiation out of which irregular accented single notes stand out as possible melodic fragments. However, these notes are so embedded in the accompanying texture that they never completely take on a definite form of their own.
E31	9'10"	Continuation of E30, notable because these attributes and features have continued for quite some time.
E32	9'30"	Sounds like Philip Glass style minimalism: repetitive rippling arpeggiation with very slow, primarily consonant harmonic movement, by stepwise single notes as the arpeggiations continue over time.
E37	10'25"	This sequence of repeated mid-register notes sounds insistent.
E40	11'10"	Silence emerges through a slow fade out of the preceding material.
E42	12'10"	The Bass Line has stopped, although I had not been conscious of its earlier presence until its sudden absence.
E43	12'20"	Dead Silence, stark and noticeable because it was in such contrast to the preceding material which did not alter in any way before this Silence. I was completely unprepared for its occurrence.
E44	12'30"	Disparate motivic fragments over chords. Each fragment is discernibly and clearly separate from the others, but don't really turn into anything definite.
E46	13'20"	Took some time to realise that nothing else was going to happen, indeed that this was in fact the end of the piece.

Stage 5. Converting the Qualitative Listening Observations into Fuzzified Data.

Converting the qualitative listening observations into fuzzified data for this experience of listening to this music centres on a particularly distinctive aspect of the qualitative listening observations of this music: significant variations in Texture in terms of the numbers of independent voices. Because defining independent attributes is a general principle of *Fuzzy IDEAS*, the major challenge in converting the qualitative listening observations for *Scharlacrote Buchstaben* into fuzzified data is determining characteristics of Texture independent from the other sources of variation in the music. This is further complicated as the nature of each independent voice changes quite frequently. This requires feature sets that describe Textural variations both between individual sound events as well as between groups of sound events.

In conventional music theory, 'Texture' is a term which describes the number of independent 'voices' in combination with the individual quality of each of those 'voices'. For example, Homophony (melody and accompaniment) conventionally suggests that there are two independent voices, one of which consists of a series of single notes, and the other a series of grouped notes (whether arpeggiations or chords). However, in this music, Texture frequently varies not only by numbers of independent 'voices', but also by variations in the qualitative nature of each independent 'voice'. Again, conventional descriptors frequently imply other things, such as describing a group of sounds as Arpeggiation implies a rapid succession of events that have a particular ordering in the pitch domain, while maintaining a steady temporal succession. Yet this is not necessarily the case for all Arpeggiation events in *Scharlacrote Buchstaben*. These difficulties are ultimately resolved by providing fuzzy feature sets over the attribute of Texture that include some specific types of independent voices such as Pedal-tones, which would more conventionally be regarded as a subset of Polyphony. As the range of possible classes of Texture embodied in individual sound events is quite significant in this music, taking advantage of fuzzy logic principles allows those events which have significant issues in classification to be included multiple feature sets for this attribute. Uncertainty is a distinct attribute of this music as it arises in a number of different ways.

Firstly, it can take time for particular features to establish themselves as distinct entities. For instance, E9 at 3'20" starts out as a series of Alternating Sounds, but by E10 at 3'35", it is clearly taking shape as Homophony, as the melodic material emerges out of the chordal structure through accentuation. Another example is E19 at 6'25", where the suggestions of melody appear and disappear in the Texture of the music. Other significant events which rely on time, include groups of repeated events, because I can only know that this group exists once the repetitions have occurred. Also, *Ritardando* where the rate of events slows down, eventually coming to complete silence can only become apparent over time, it cannot be known at the start of this series of events.

Secondly, uncertainty in classification arises from the nature of some sound events, as they contain multiple features which belong to a range of possible Textures. For instance, in the section, which sounds quite minimalist, E30-E34 at 8'55" to 9'55", is it best to describe the material as Polyphonic or as Homophonic. This question arises as there is no accented melody 'voice' separate from the arpeggiations, yet it is possible to discern a distinct type of melodic movement in the highest notes of the arpeggiations.

Thirdly, at other times, I became aware of something only because some new occurrence had brought the feature to conscious awareness, such as E14 at 4'40", where the melody became apparent, yet at this time-point I also realised that the melodic shape was in existence prior to my conscious perception. Another example is E42 at 12'10". This event occurred simply because I had become aware that the Bass line had dropped out of the repeated arpeggiations. However, it was not until its absence that I realised that the bass line had been present in the first place.

The fuzzy entities I selected for classifying technical attributes and features are shown in Table A.2. *Scharlachrote Buchstaben*: Technical Attributes and Feature Sets below. This table shows the technical details in the qualitative listening observations organised into attributes and then feature sets. This classification is designed to cover the sounds of this music in the most comprehensive yet efficient way. These attributes and feature sets will be used to represent this listening experience in visual form.

Table A.2. *Scharlachrote Buchstaben*: Technical Attributes and Feature Sets

Attribute	Feature Sets		
Time	The smallest time interval between recorded events is 5"		
Amplitude	Louder		Getting Softer
Register	Very High	High	Mid
	Low	Low Mid	Bass
Tempo	Rapid	Getting Slow	Slow
	Fast	Steady	Getting Very Slow
Texture	Polyphony: interactive similar groups of sounds Homophony: two groups with some distinctive technical qualities Monophony: groups of single notes or chords of the same sound type Pedal Tones Alternating Sounds Repeating Sounds Single Sound Events		

Stage 6. Constructing Visual Representations of the Fuzzified Data

The purpose of this stage is to report the fuzzified data in a visual format which directly represents various aspects of this personal experience of the music. The visual representations are constructed from the fuzzified data for each sound event at both attribute and feature set level. The quantisation interval selected for mapping the fuzzified data into the visual representations is based on the smallest time interval between the quantised time points, which here is five seconds.

The fuzzified data in time series at the attribute level gives the single most complete overview of the listening experience. This visual representation is provided in Figure A.1 below. By contrast, the fuzzified data at the feature set level across time gives the most detailed visual representation of the listening experience. This level of detail requires multiple visual representations which are presented in Figure A.2- Figure A.7 (see pp. 289-291 below).

a. Attribute Combinations across the Time Domain

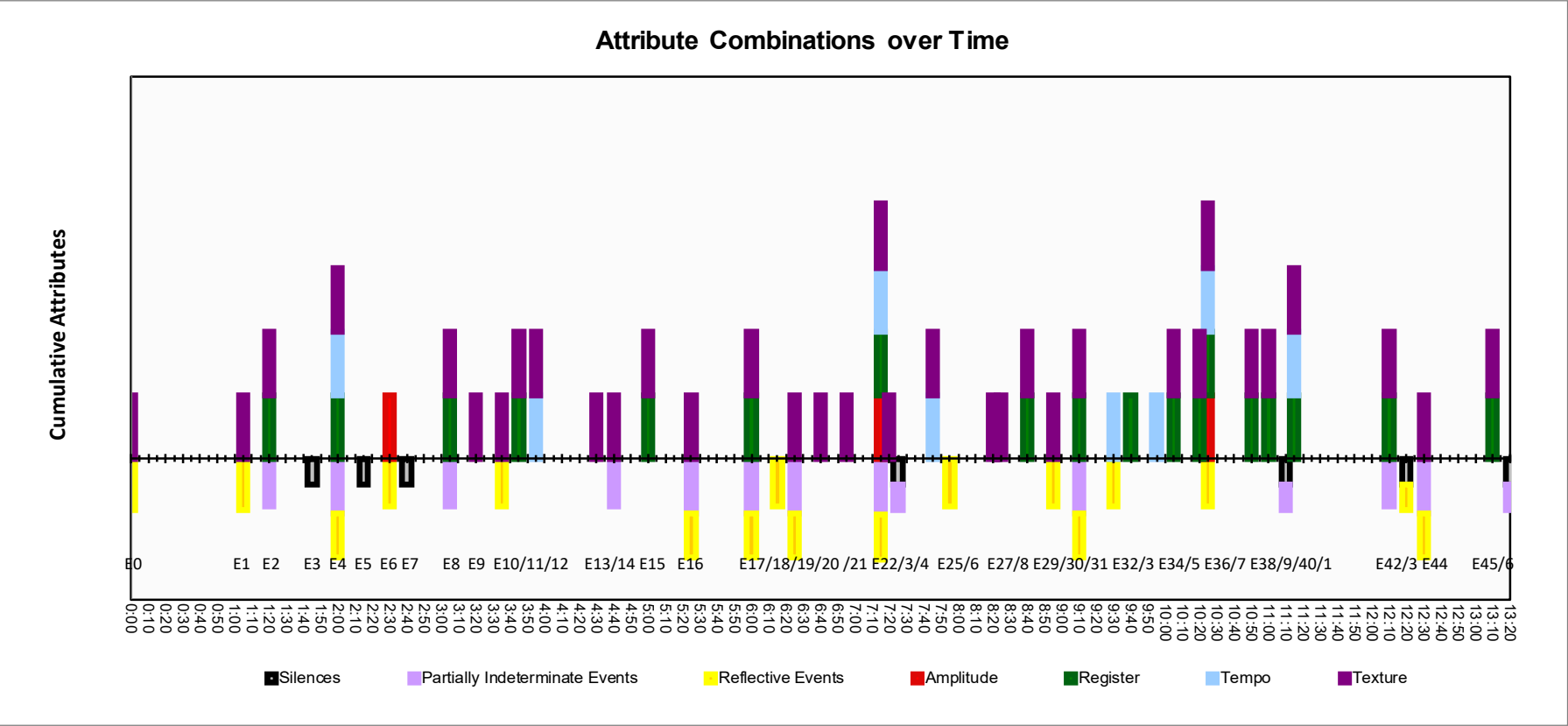


Figure A.1. *Scharlachrote Buchstaben*: Attributes across the Time Domain

b. Fuzzy Feature Sets across the Time Domain

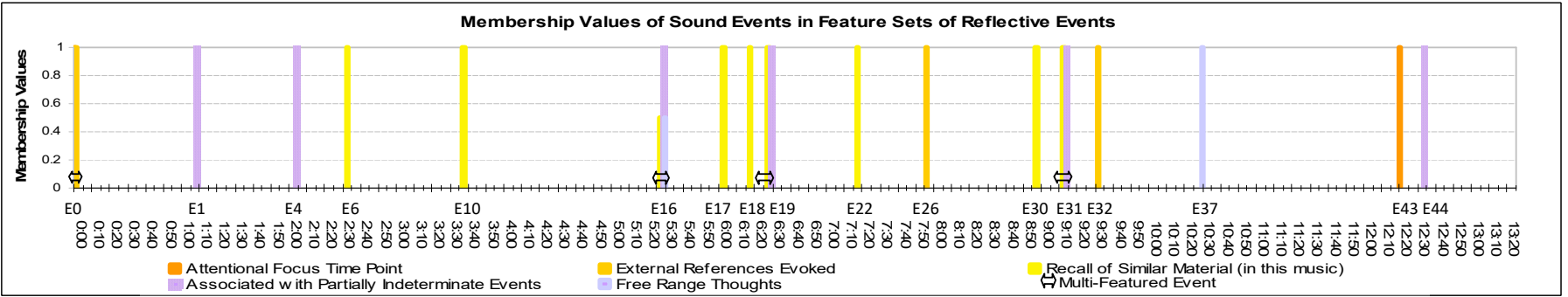


Figure A.2. *Scharlachrote Buchstaben*: Feature Sets of Reflective Events over Time

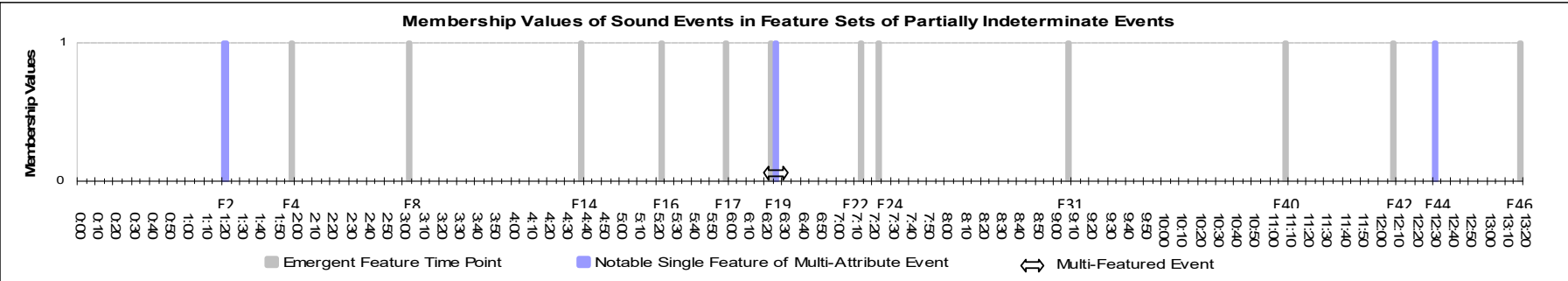


Figure A.3. *Scharlachrote Buchstaben*: Feature Sets of Partially Indeterminate Events over Time

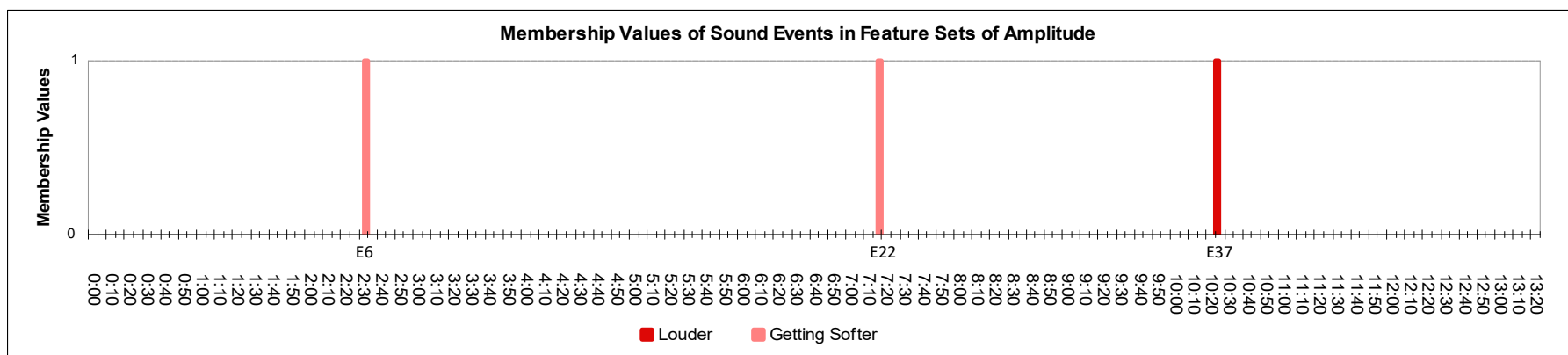


Figure A.4. *Scharlachrote Buchstaben*: Feature Sets of Amplitude over Time

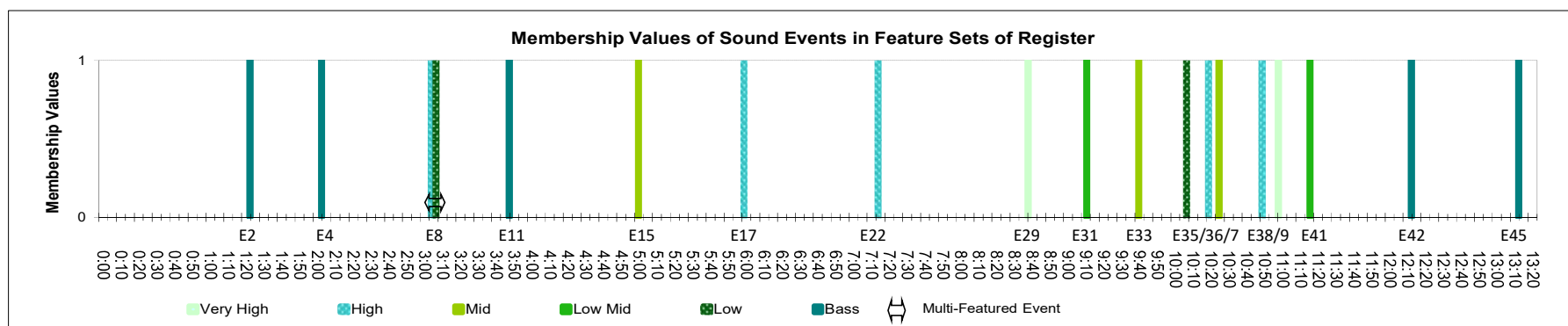


Figure A.5. *Scharlachrote Buchstaben*: Feature Sets of Register over Time

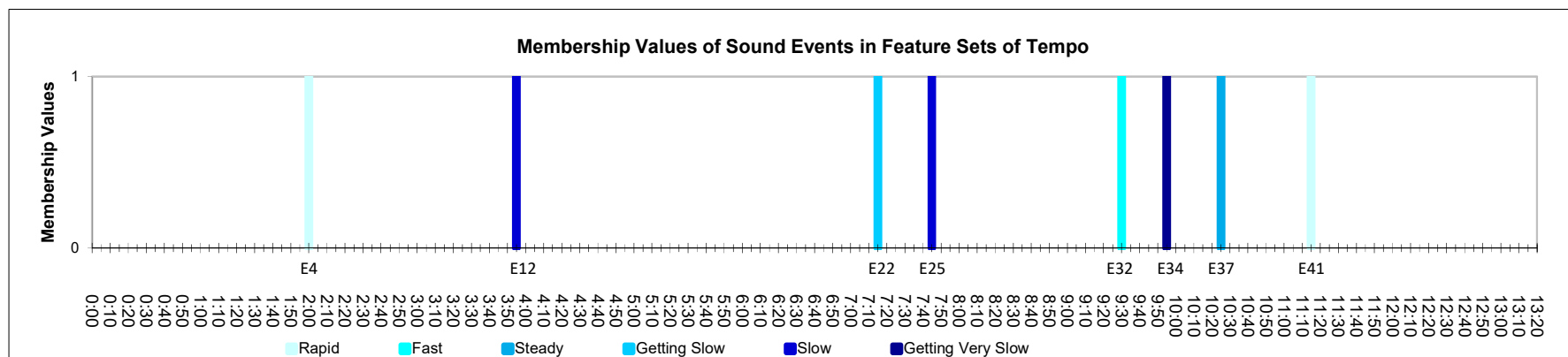


Figure A.6. *Scharlachrote Buchstaben*: Feature Sets of Tempo over Time

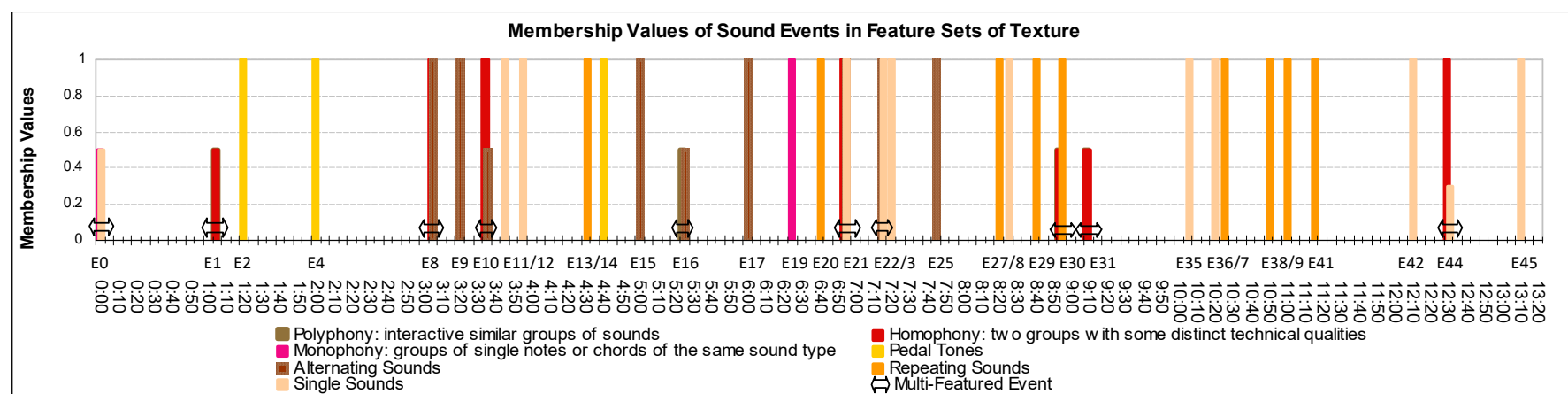


Figure A.7. *Scharlachrote Buchstaben*: Feature Sets of Texture over Time

Stage 7. Analysing the Frequency of Fuzzy Entities in the Visual Representations

This stage summarises the information conveyed by the visual representations to draw out those attributes and features highlighted in this single experience of the music. These significant occurrences imply that these particular qualities have been emphasised by the composer. Relative frequency of attributes and feature sets also indicates the amount of variation between individual sound events.

a. Frequency of Attributes

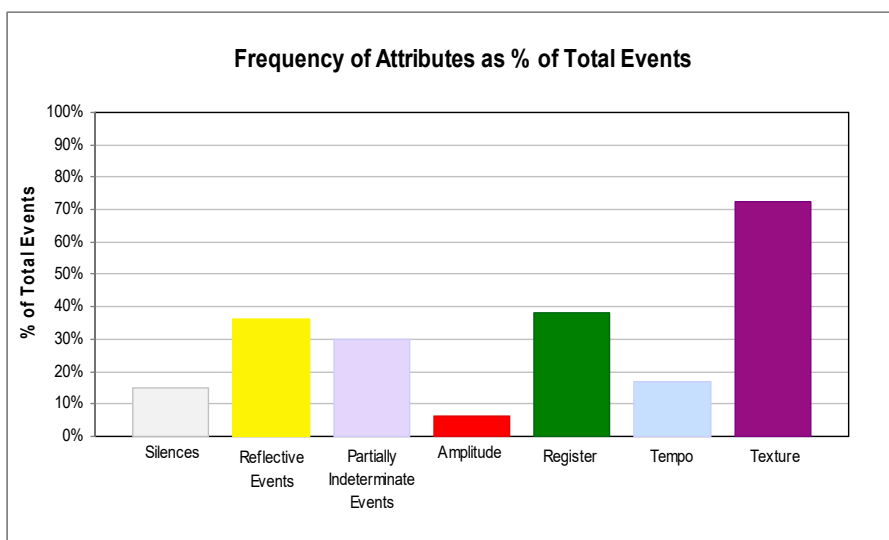


Figure A.8. *Scharlachrote Buchstaben*: Frequency of Attributes

This experience of this music is described by seven attributes: four Technical attributes, Silences, and the two Cognitive attributes - Reflective Events and Partially Indeterminate Events.

This music has prompted Reflective Events for 36% of total events, while 29% of total events are Partially Indeterminate.

14% of total events are Silence Events.

By far the most common attribute is Texture, which has been recorded for 72% of all events; 38% include Register, while Tempo is included in 17% and Amplitude appears in 7% of total sound events.

b. Frequency of Sound Events in Technical Feature Sets

Each attribute is broken down into its constituent fuzzy feature sets. Figure A.9 below is a set of histograms, each of which shows the proportion of total sound events included in each individual feature set within an attribute.

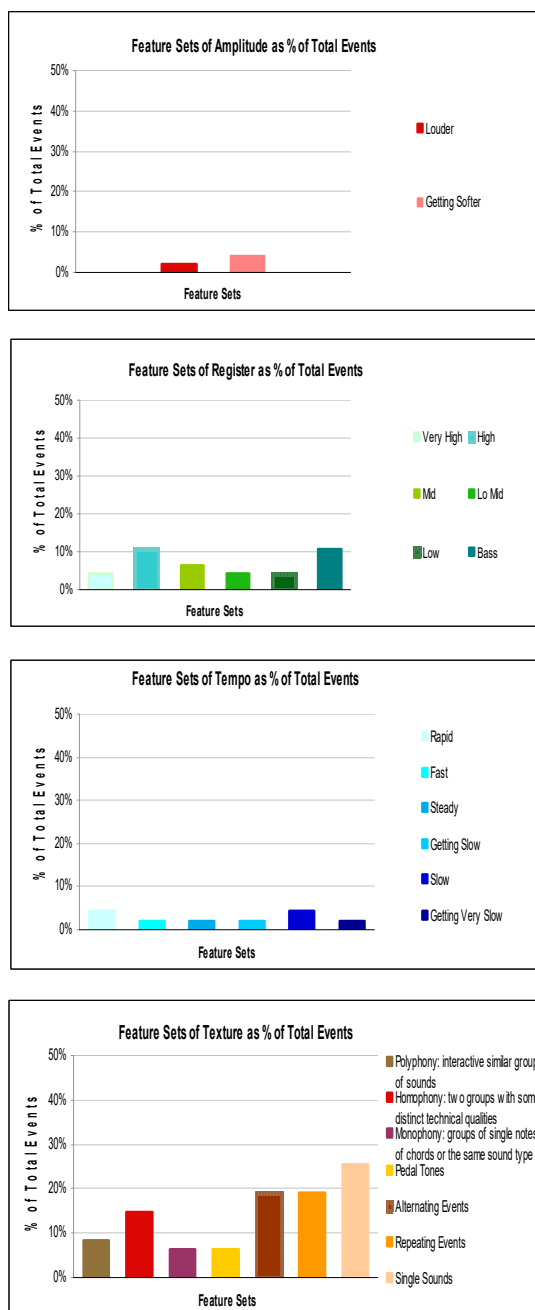


Figure A.9. *Scharlachrote Buchstaben*: Frequency of Technical Feature Sets

By far the most dominating attribute is Texture, which has been recorded for 72% of total events in seven feature sets. 25% of total events are characterised as Single Sounds, 19% are Alternating Sounds, 19% are Repeating Sounds, and 14% are Homophonic.

Amplitude is relatively infrequent (6% of total events), containing only two feature sets for three events in total. Register is present in 38% of total events in six feature sets. Of these the most common are High and Bass which each contain 10% of total events.

By comparison, Tempo is only included in 17% of total events, but also contains six feature sets which together contain eight sound events. The most common feature sets are Rapid and Slow which each contain 5% of total events.

c. Frequency of Feature Sets of Partially Indeterminate Events

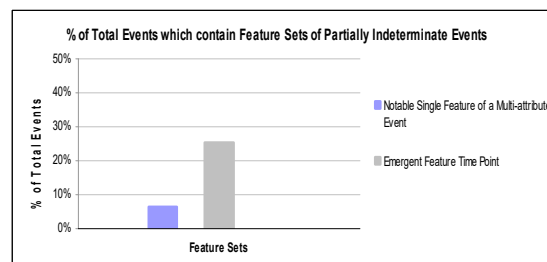


Figure A.10. *Scharlachrote Buchstaben*: Frequency of Feature Sets in Partially Indeterminate Events

The highest ranking feature set is Emergent Feature Time Point, which is included in 25% of individual event descriptions, one of the feature sets with the most elements among all the attributes.

d. Frequency of Feature Sets of Reflective Events

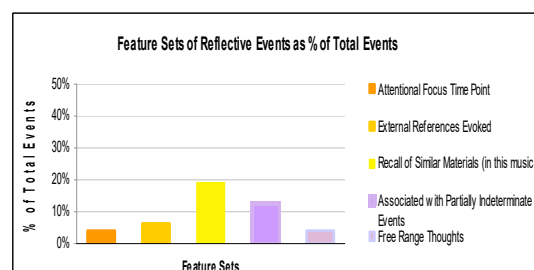


Figure A.11. *Scharlachrote Buchstaben*: Frequency of Feature Sets in Reflective Events

Nine sound events (19% of total events) are Reflective Events that Recall Similar Materials have already occurred in this music, while 6% have been categorised as Referencing Music External to *Scharlachrote Buchstaben*. By comparison, 12% are associated with Partially Indeterminate Events, and only two events (4% of total) are Attentional Focus Time Points.

e. Frequency of Attribute Combinations

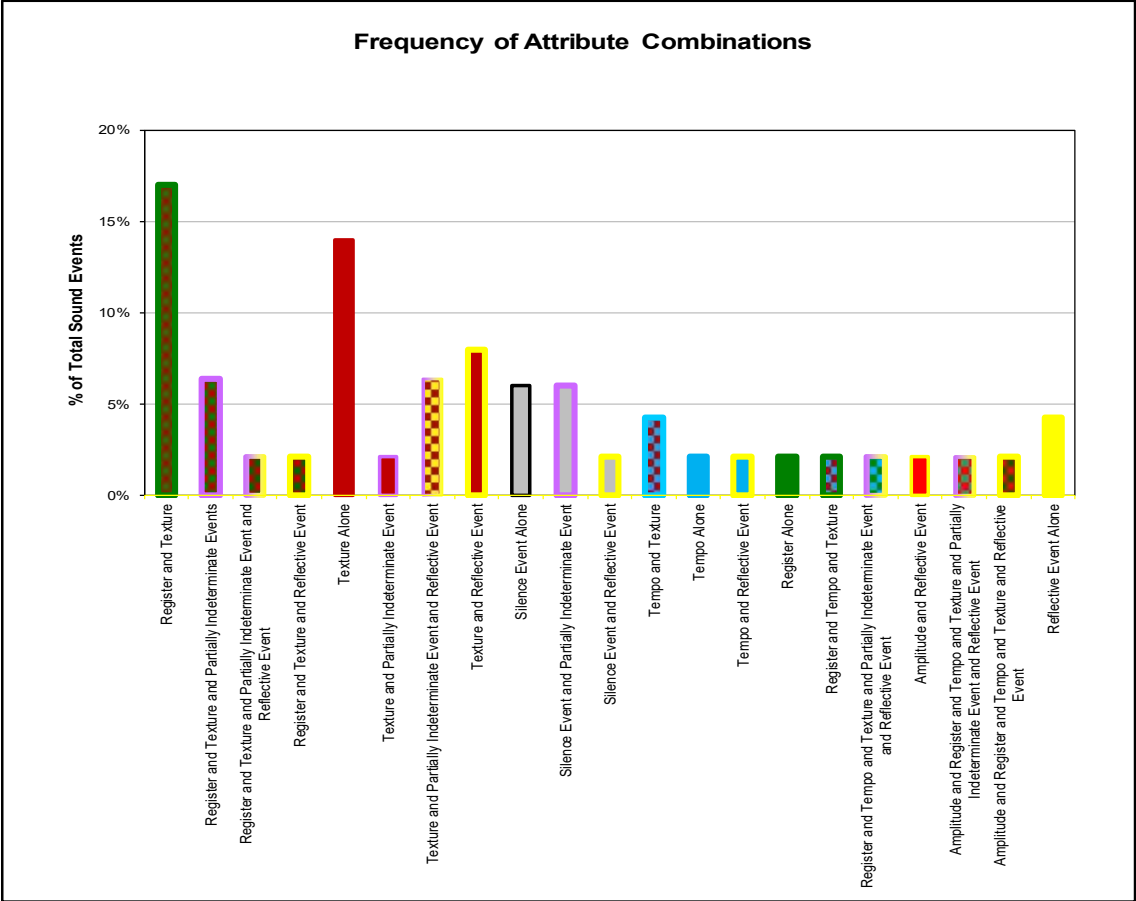


Figure A.12. *Scharlachrote Buchstaben*: Frequency of Attribute Combinations

The Frequency Distribution of Attribute Combinations shows the most and least common combinations of attributes, as well as the similarity between all events at the attribute level.

Reflective Events Alone are included in 4% of total events.

Silence Events Alone account for 6% of attribute combinations, as do Silence Events with Partially Indeterminate Events. There is one sound event (2% of total sound events) which is Silence and Reflective Event

By contrast 18% of total events are identified by only one technical attribute: Texture Alone 14%, Tempo Alone 2% and Register Alone 2%.

In *Scharlachrote Buchstaben* the most complex events could have a maximum of four technical attributes excluding Reflective Events, Partially Indeterminate Events and Silences. There are two sound events that contains all four attributes. Register and Texture occur eight times during the music, which accounts for 17% of total events, Various combinations of Partially Indeterminate Events and Reflective Events add another 10% to the overall number of sound events containing combinations of Register and Texture. Further, Texture Alone occurs in another 14% of sound events. While Texture and Partially Indeterminate Event occurs in only one sound event, Texture and Partially Indeterminate Events and Reflective Event occurs in three (6% of total) events, although Texture and Reflective Events occur in 8% of total events.

a. Frequency of Transition Pairs

Table A.3 below shows only the duplicated Transition Pairs for this music. Transition Pairs that only occur once are not included in this table. This table is result of a comprehensive comparison of all attributes between adjacent sound events across multiple attributes. Cognitive Events, including Reflective Events and Partially Indeterminate Events are included in these Transition Pairs.

Table A.3. *Scharlachrote Buchstaben*: Repeated Transition Pairs at Attribute Level

Attributes of First Event	Attributes of Adjacent Event	Event Pairs	Number Identical Pairs	% of Total Transition Pairs
Texture Alone	Texture Alone	E20-E21 E27-E28	2	4%
Register and Texture	Register and Texture	E35-E36 E38-E39	2	4%
Register and Texture	Silence Event and Partially Indeterminate Event	E39-E40 E45-E46	2	4%

The vast majority 40 (86%) of total Transition Pairs occur only once in the whole piece. Reflective Events are included in 26 (56%) of the Transition Pairs, while 24 (52% of total) Transition Pairs include a Partially Indeterminate Event.

Three Transition Pairs occur twice each throughout the whole of the music. The two attribute-identical Transition Pairs of Texture Alone to Texture Alone (E20-E21 at 6'40"-6'55", and E27-E28 at 8'20"-8'25"), and Register and Texture to Register and Texture (E35-E36 at 10'05"-10'20", and E38-E39 at 10'50"-11'00"). The third repeated Transition Pair is Register and Texture to Silence Event and Partially Indeterminate Event (E39-E40 at 11'00"-11'10", and E45-E46 at 13'10"-13'20").

Stage 8. Analysing the Time Structure of the Visual Representations

The second type of analysis on the fuzzified data explicitly focusses on visual analysis of the time-patterning of attributes, features, and Silence events. This is achieved by constructing a set of analytical charts from the time point visual representations. Each analytical chart addresses a single aspect of the time point representations of the fuzzified data.

a. Time Structure of Attributes of Silence Events

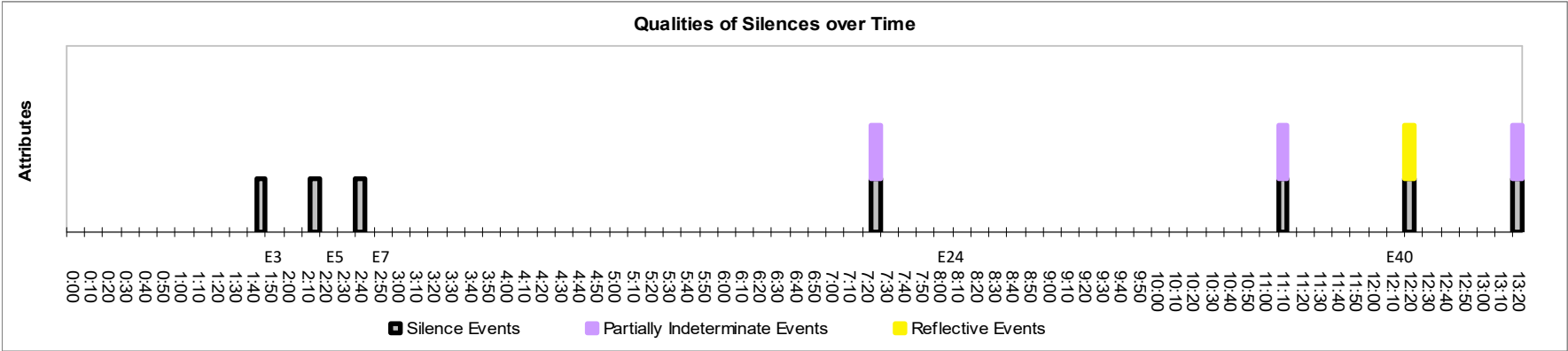
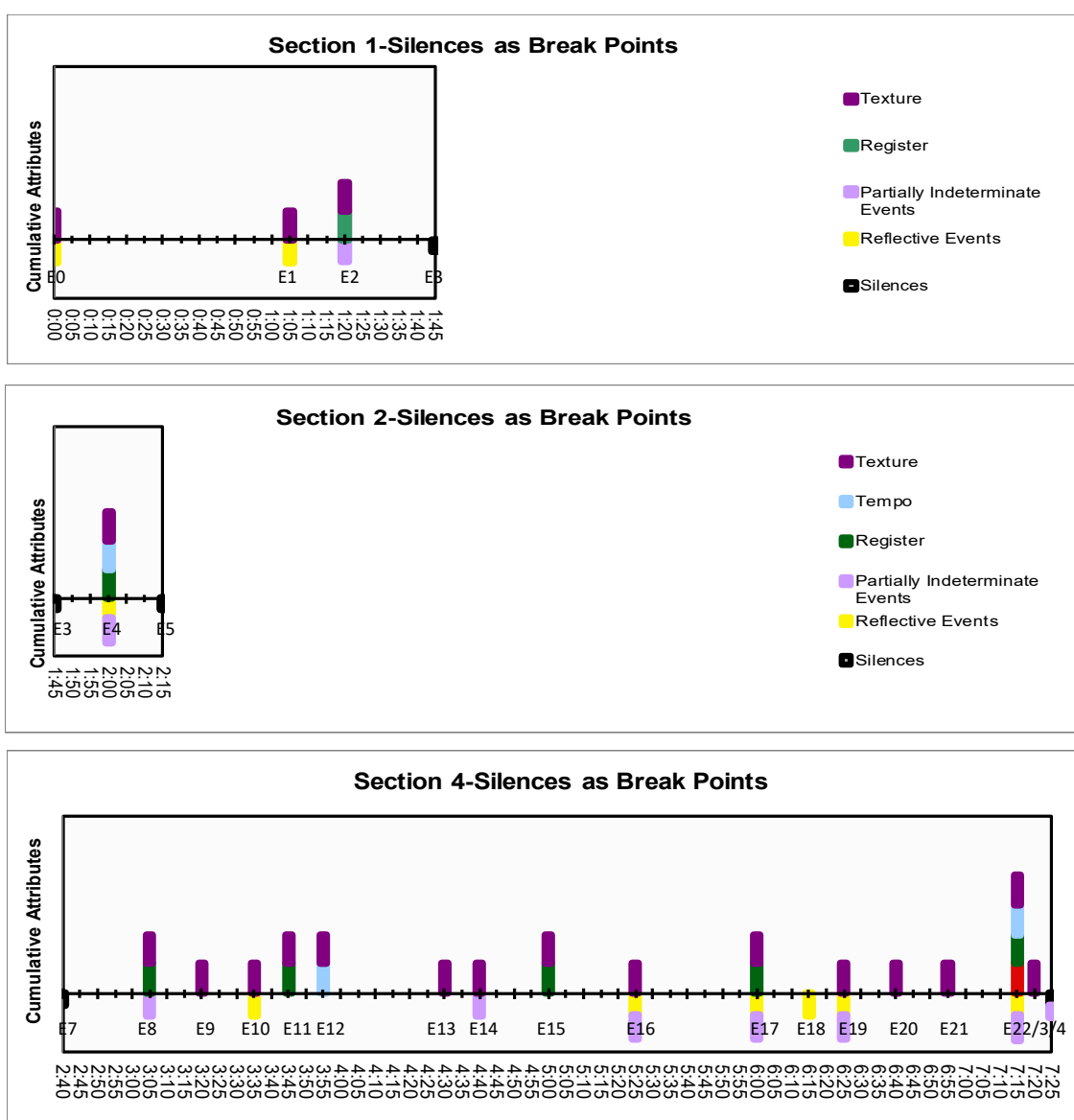


Figure A.13. *Scharlachrote Buchstaben*: Silences and their qualities over Time

Three Silences Only events occur between 1'45" and 2'40";. The single Silence event at 7'25 (E24) cuts the music into two unequal parts, but has more than one attribute and thus is related to the second grouping of three complex Silences that occurs between 11'10" and 13'20", an expanded time frame compared with the first group. The duration of the music from the first complex Silence event to the final Silence event is 5'55", while the final group of three marks the final third of this second part.

b. Sectional Segmentation by Silence Events

This part of the analysis explores the sectional structure where the duration of each section is determined by the timing of Silence Events. The overall duration of each section and the attributes of events in each section are shown in Figure A.14 below.



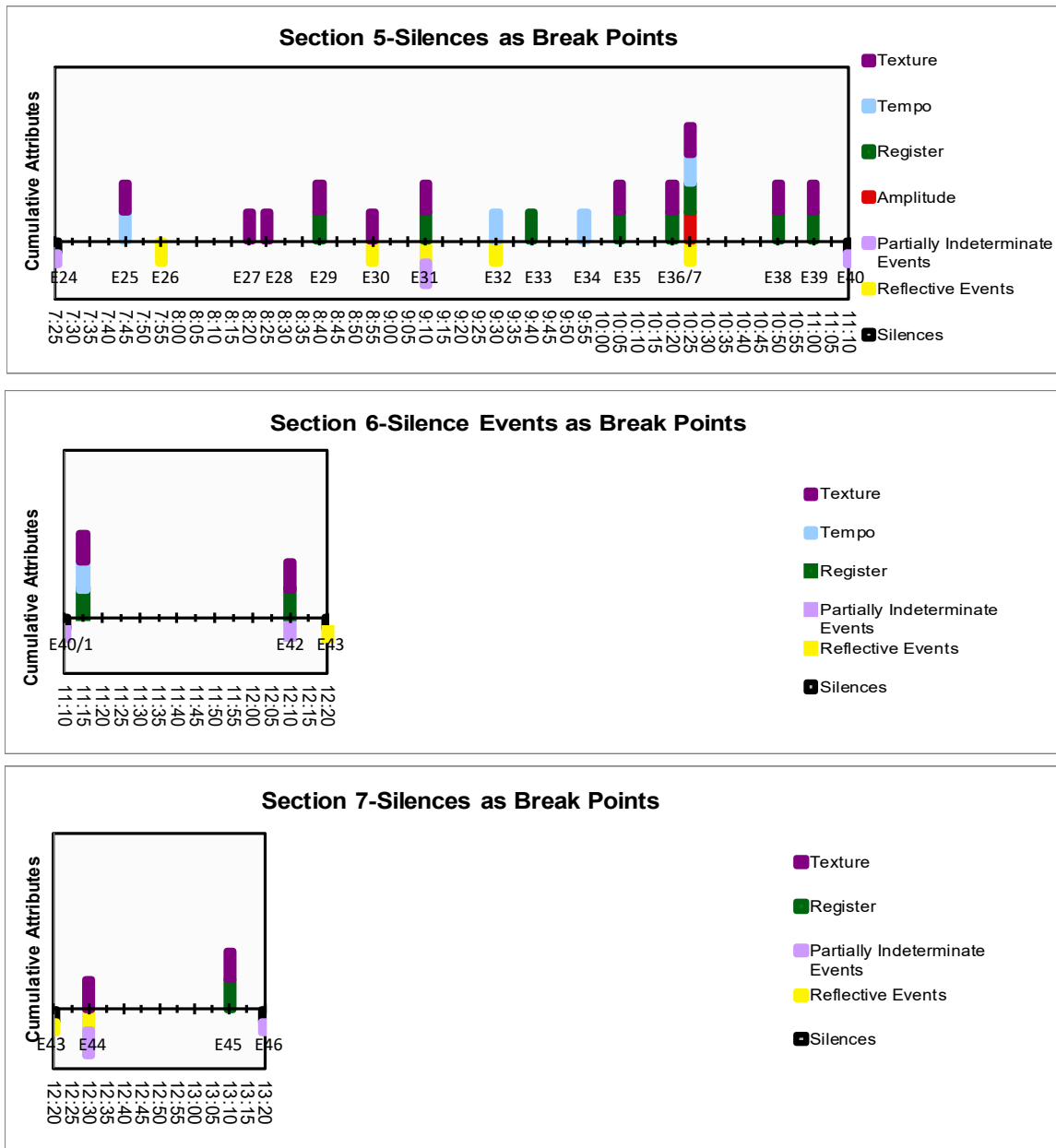


Figure A.14. *Scharlachrote Buchstaben*: Segmentation using Silence Events as Break Points

Section 1 is different from all the others while having visual parallels with both Section 5 and the final Section 7. It is similar to Section 5 in that both have their most complex event occurring at about 75% of elapsed time in that section. Yet, Section 1 is similar to Section 7 as both sections have a noticeable period of inactivity bound by events which are only moderately complex.

Sections 2 and 3 have very similar structures over fuzzily identical short time frames of 45" and 35" respectively. The only variation is the difference in attributes of the sound events. The time structure of Sections 2 and 3 are a reversal of the time structures of sections 1 and 7 because 1 and 7 have events at both ends, while 2 and 3 have events in the centre.

Sections 4 and 5 are both very long, 4'45" and 3'45" respectively, in comparison to all the other sections. Sections 4 and 5 also include the most complex events of the complete experience. Each complex event occurs towards the end of the section, E22 at 7'15" occurs 10" before the end of Section 4, while E37 at 10'25" occurs 45" before the end of Section 5.

Sections 6 and 7 are of similar length, 1'10" and 1'00" respectively. They are also similar in terms of structure across time. Yet, these short sections are nearly double the duration of Sections 2 and 3, while their internal structures are reversals of the internal structures of Sections 2 and 3.

c. Event Complexity over Time

This section shows where both the most complex events and the most simple events lie on the Time Domain. Figure A.15. *Scharlachrote Buchstaben*: Max-Min Technical Attributes across Time below summarises Figure A.1. *Scharlachrote Buchstaben*: Attributes across the Time Domain (see p. 288 above) to show those sound events which have the most and the least technical attributes. Figure A.16 below presents the configuration of Partially Indeterminate Events to show the distribution and amount of uncertainty over time. These events contain some uncertainty regarding their definition, in both senses of the word: boundaries are vague, or there is difficulty with Sound Source identification. Partially Indeterminate Events are by definition more complex than other sound events because of this uncertainty.

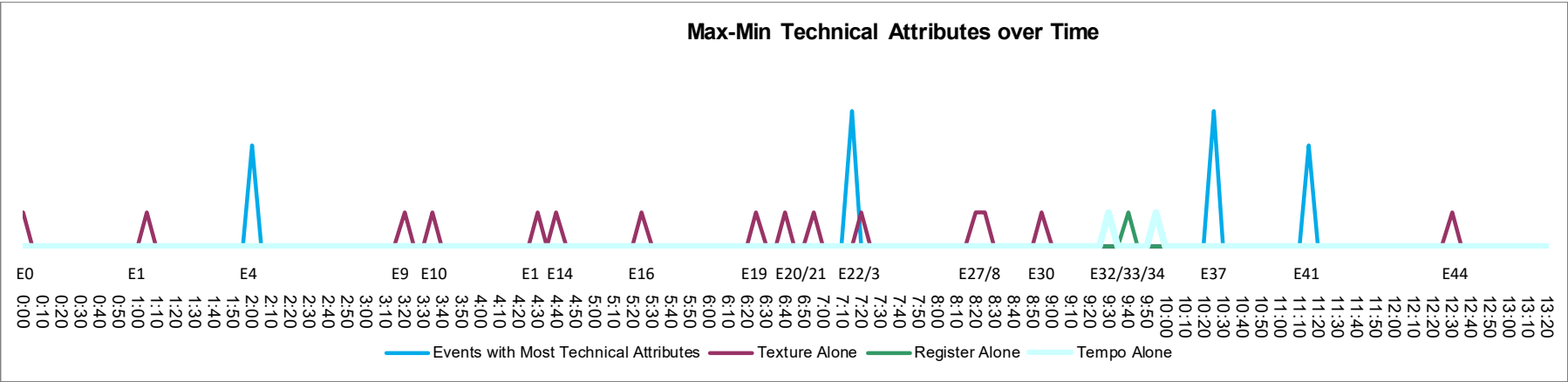


Figure A.15. *Scharlachrote Buchstaben*: Max-Min Technical Attributes across Time

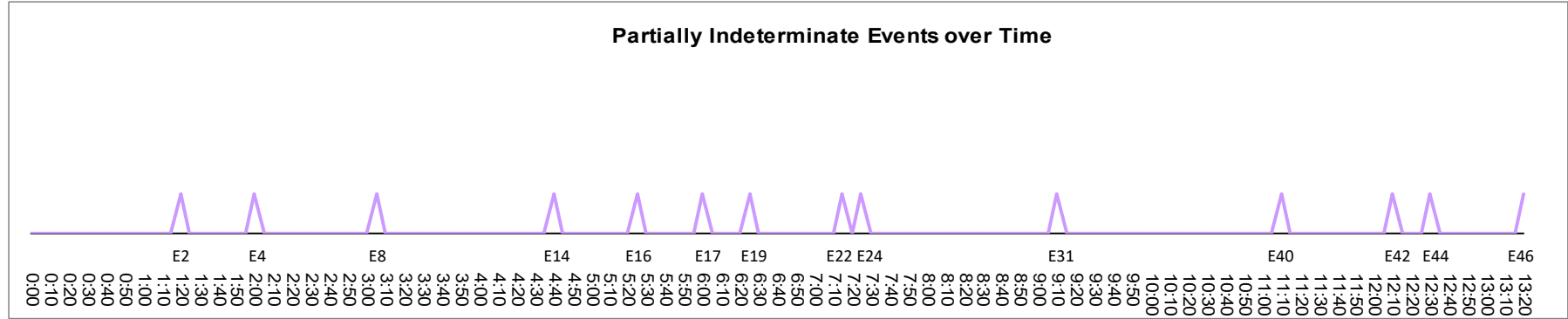


Figure A.16. *Scharlachrote Buchstaben*: Partially Indeterminate Events across Time

The most complex technical events in *Scharlachrote Buchstaben* have four simultaneous technical attributes. E22 at 7'15" occurs at a time interval of 6'05" before the end of the music, while E37 at 10'25" divides this second section into fuzzy¹ halves of 1'55" duration. This division does not occur in the first section of the music. The next most complex events each have three technical attributes. E4 at 2'00" and E41 at 11'15" occur at fuzzily equidistant times from each end of the music. The least complex events have only one attribute, most frequently Texture Alone. However, there are three other single-attribute events, which occur as a group. Two are Tempo Alone, which frame the single event of Register Alone. Interestingly, the majority of single-attribute Texture events occur before the other two single-attribute Events. Apart from this, there are no immediately discernible patterns over the time domain.

The time between the single attribute Texture Alone events E1 at 1'05" to E9 at 3'20" is 2'15", which is a similar duration to the group from E9 to E16 at 5'25". This sequence does not continue. There is a regularity of about 1' duration between many events, for instance E1 to E4, E10 to E13, E13 to E16, E16 to E19, E19 to E23, E23 to E27, E28 to E32, E32 to E37. However, this pattern is not continuous and breaks down towards the end of the music.

The Partially Indeterminate Events tend to be in groups, although fewer occur after E22 at 7'15".

The most discernible patterns over the time domain is that event complexity on two different dimensions of both technical complexity and documented uncertainty tends towards an interlocking pattern, because only about 25% the events in the two analytical charts, Figure A.15 and Figure A.16 coincide. This pattern occurs as the Partially Indeterminate Events predominantly occur at those times when neither one of the most complex nor single-attribute events is occurring. However, the events that do coincide occur at 4'40" (E14), 5'25" (E16), 6'25" (E19), 7'15" (E22), and 12'30" (E44).

¹ Here using 'fuzzy' to mean a close approximation, in that visually it appears the duration between events is equivalent, however if measured precisely on the time axis it is evident that the time interval is not identical.

d. Most Common Attribute Combinations over Time

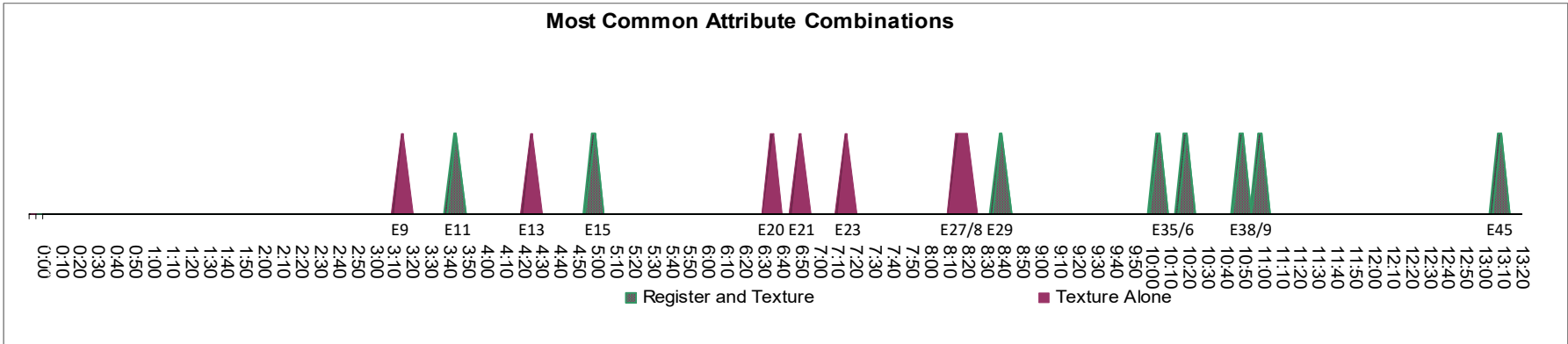


Figure A.17. *Scharlachrote Buchstaben*: Most Common Attribute Combinations across Time

The music as a whole is examined for the time points of the Most Common Attribute Combinations, looking for obvious replications of sound events with identical attribute combinations across the time domain. This analytical chart includes all attributes, cognitive as well as the technical attributes. This is different than the previous analysis of the contour of technical complexity, because it places cognitive events on an equal footing with any technical attribute(s). For some listeners, cognitive events may be their primary way of responding while listening to the music. In these instances, this analytical chart allows that information to rise to the surface. Overall, this analytical chart provides information on whether and when specific sound events with identical components are repeated. This information can imply repetition or variation as the music unfolds which gives another insight into possible formal structures such as Rondo, where the opening theme is repeated several times after interjected alternate sections.

The first of the frequent Attribute Combinations is E9, at 3'20", which is a Texture Alone Event. The first Register and Texture sound event occurs at E11 at 3'45", and also E13 at 4'30" alternating with another Texture Alone Event until E15 at 5'00". This group of alternating combinations has a duration of 1'40", half the duration of the time interval before E9 at 3'20". There are further suggestions that 1'40" is significant because the five Texture Alone events from E20 at 6'40" to E28 at 8'25" occur in the same time interval of 1'40". Then, however, Texture Alone does not recur in the remainder of the music. Instead the Register and Texture events immediately dominate the music, from E29 at 8'40" to E45 at 13'10". These six events occur in a mirror pattern in this time interval of 4'30".

There are individual sound events with the attributes of Register Alone and Tempo Alone events, E33 at 9'40" and E34 at 9'55" respectively, which occur in the second half of the music.

e. Repeated Transition Pairs at Attribute Level

Figure A.18 below shows only the duplicated Transition Pairs for this music.

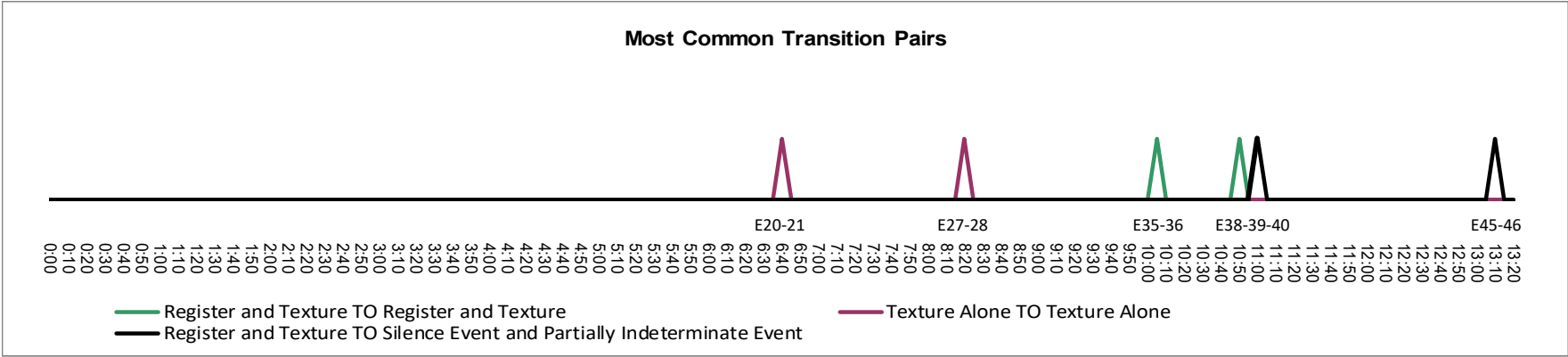


Figure A.18. *Scharlachrote Buchstaben*: Repeated Transition Pairs across Time

In this experience of the music the repeated Transition Pairs all occur in the second half of the music, and occur sequentially.

The first repeated Transition Pair E20-E21 occurs at 6'40", the exact mid-point of the music. The second pair of repeated transitions E27-E28 occurs at 8'20". This time interval of 1'40" is fuzzily identical to that which occurs between this pair and the final pair of repeated transitions E35-E36 which occurs at 10'05".

However, this pattern breaks down for the final set of Transition Pairs E39-E40 which begins at 11'00".

f. Time Structure of Feature Sets

This is an overview of the set of visual representations of feature sets over time presented in Figure A.2-Figure A.7 (see pp. 289-291).

Reflective Events that are Multi-featured begin with E0 at 0'00", then at 5'25" (E16), then 6'25" (E19) and 9'10" (E31).

The feature sets of Reflective Events interleave over the whole of the music. Those that are Attentional Focus Time Points occur at E0 at 0'00" and E43 at 12'20", and two Free Range Thoughts: E16 at 5'25" and E37 at 10'25". Recall of Similar Materials all occur between 2'30" and 9'10", while two External References occur at 7'55" (E26) and 9'30" (E32). There are groups of events with fuzzily similar time intervals occurring at 2'00" to 2'30" (E4-E6), 6'00" to 6'25" (E17-E19), 8'55" to 9'30" (E30-E32), which then break down for the final group 12'20" to 12'30" (E43-E44).

Partially Indeterminate Events include one Multi-featured event at 6'25" (E19) which is very close to the Time Centre of the music which occurs at 6'35". Events for which only one Feature is Notable among other Attributes bookend the piece at 1'20" (E2) and 12'30" (E44), while also included in the Multi-featured event E19 at 6'25". These Notable Single Feature events break up the music into two regular segments around the time centre/mid-point of the music. Although there are twelve Emergent Feature Events, they do not show such a regular patterning, although five occur in the first half of the music bounded by the Notable events, and five in the second half bounded by the Notable Events, while the central E19 also includes this Feature as does the final Silence Event.

Amplitude grows louder over the course of this experience of the music. The three Amplitude events occur at 2'30" (E6), 7'15" (E22) and 10'25" (37).

There is one Multi-featured event in Register at 3'05" (E8). The Bass events occur at both ends of the music: E2 at 1'20" and E4 at 2'00"; then E42 at 12'10" and E45 at 13'10", with one additional event in the first part of the music, E11 at 3'45." The only events identified as Low, E8 at 3'05" and E35 at 10'05", both occur close to 3'00" from either end of the music. From E29 at 8'40" to E41 at 11'15", the music becomes relatively hectic as it continues to swirl through a number of Registers at a relatively rapid rate. This short time interval contains eight of the 17 sound events with this attribute.

The initial feature set of Rapid returns again at the end of the music in a mirror of the opening. E41 at 11'15" to the final event, E46 at 13'20", a fuzzily similar time interval to E0 at 0'00" to E4 at 2'00". Slow Events occur at approximately one-third and two-thirds of the total duration of the music. The feature sets of Getting Slower, E22 at 7'15", and Getting Very Slow, E34 at 9'55", mark time points when the Tempo was actually changing. They both occur in the second half of the music, interspersed with a Slow event, E25 at 7'45", and the only Fast event, E32 at 9'30". Hence Tempo is more variable in the second half of the music and also changes most rapidly around the 10'00" mark.

In the attribute of Texture, ten Multi-featured events occur throughout the music. Particularly noticeable are E16 at 5'25" and E44 at 12'30" which occur by themselves. By comparison, E0 and E1 are both Multi-featured and occur 1'05" apart. The other six Multi-featured events occur in smaller but fuzzily identical time intervals: 3'05" to 3'35" (E8-10), 6'55" to 7'20" (E21-E23), 8'55" to 9'10" (E30-E31).

There is a pair of Single Sound events, E11 at 3'45" and E12 at 3'55", which is similar to the pair of Single Sound events, E35 at 10'05" and E36 at 10'20", which are similar distances from the beginning and end of the music respectively. The three Pedal-tone events all occur in the first third of the music, E2 at 1'20", E4 at 2'00" and E14 at 4'40". The pattern of Repeating Events overlaps with the Pedal-tone sound events. The first Repeating event occurs at E13 at 4'30", then at E20 at 6'40", and E27 at 8'20", which are each six events apart as well as approximately two minutes

apart. However, from E27 at 8'20" to the last sound event in Repeated Events three minutes later, E41 at 11'20", there are five additional events with this Feature. It is difficult to discern any regular pattern in the timing of events with features of Texture, but there do seem to be distinct groups of events with particular features in various time intervals, which either include or be separated by one or more of the Multi-featured Texture events. Particular feature sets tend to occur in particular parts of the music. For example, Repeating Sounds only occur between 4'30" and 11'15" (E13-E41), while Alternating Sounds only occur between 3'05" and 7'45" (E8-E25).

Stage 9. An Abductive Interpretation: The Idea that Makes Sense of this Experience

This stage draws out the overall key idea suggested by this experience of the music, and what this experience suggests about the compositional design. These abductive conclusions follow through on earlier hypotheses formulated immediately before listening presented in Stage 1, and immediately after listening presented in Stage 3, as well as the implications of the analyses presented in Stages 7 and 8. Here, in Stage 9, this synthesis links the technical features observed during listening and the previous hypotheses, to draw conclusions about the idea that makes sense of this experience.

a. Implications of Frequency of Technical Attributes, Attribute Combinations, and Feature Sets

The dominant attributes and features suggest that these sonic qualities have been emphasised by the composer, while the frequency of occurrence of sound events and the range of feature sets indicate the amount of variation between sound events.

The high number of features sets required to accommodate the range of events in Register, Tempo and Texture demonstrates the variability between sound events despite the possible limitations of the music being composed for conventional solo piano.

The large number of feature sets in Register was required to cover sound events which occurred over the complete range of Registers possible on this instrument. About 2 out of 5 events include Register.

Tempo was also quite significant in that it came to my attention in 1 out of every 6 sound events. The number of feature sets indicates there were considerable variations between sound events.

However, Texture was the most significant attribute in terms of total number of sound events. Single Sounds, Alternating Sounds and Repeating Sounds dominate as they account for 2 in 3 sound events. The Polyphonic feature sets account for about 1 in 4 sound events.

The two attribute combinations of Register and Texture, and Texture Alone, are the most common, which together account for about 1 in 6 sound events.

These results imply that the composer is primarily using Texture and Register as the main attributes, while most sound events are individually differentiated from each other rather than being directly repeated.

Further, the vast majority of total Transition Pairs occur only once in the whole piece. Three Transition Pairs are repeated. Texture Alone to Texture Alone are matched by Register and Texture to Register and Texture and Register and Texture to Silence Event and Partially Indeterminate Event.

The other five Silence Events were approached differently. This low level of repetition in Transition Pairs and the approaches to Silence Events reinforces the idea of continual variation among events across the whole music.

b. Implications of the Uncertainty Experienced by this Listener

Uncertainty is suggested by various aspects of the results. It is reflected by the number of Multi-featured events; the number and types of Partially Indeterminate Events; and the qualities of the Silence Events.

Multi-featured events denote the ambiguous nature of individual sound events that contain elements pertinent to several feature sets in the same attribute. Partially

Indeterminate Events by definition denote events with uncertain boundaries, whether in the time domain or the technical description.

In this experience of the music, nearly 1 in 4 sound events in Texture are Multi-featured events. Although Multi-featured events occur in other attributes they are not as frequent.

Nearly 1 in 3 sound events across all attributes are classified as Partially Indeterminate Events. Emergent Feature Time Point is included in 1 in 4 individual event descriptions. Emergent Feature Time Points occur at those time points when the listener becomes aware of something only because continuation had brought it to consciousness.

Over half of the Silence events have additional attributes. This implies that there the composer has generated a sense of uncertainty regarding the convention that significant Silences mark the end of the music. The abductive conclusion is that there is no strong narrative flow throughout the music.

Although uncertainty is a necessary condition of listening because some features need time to elapse before that particular feature can be established as a distinct entity, this aspect of time is particularly relevant to Texture in this experience of this music. For example, I cannot know on hearing the first event alone that this event is going to be Repeating. I can only know I am hearing a group of Repeating Events once the repetitions have occurred.

The large numbers of Multi-featured events, and the total number of events and need for seven feature sets in Texture shows that this source of uncertainty is particularly relevant in this experience of this music. This implies that continuous variation is an important idea in *Scharlacrote Buchstaben*.

c. Implications of Reflective Events

Reflective Events are contained in 2 out of 5 total events. Reflective Events includes five feature sets. *Scharlachrote Buchstaben* is quite self-referential as well as containing the occasional reference to other styles of keyboard music.

d. Implications of the Time Domain: Silences as Break Points

Visual analysis shows that sectional relationships clearly exist between a number of section pairs either in the Time Domain or in the contour of Event Complexity. The existence of these relationships logically implies that all the sections are related to each other through other less obvious structural resemblances, although over quite different time frames.

Logical relationships between sections can be deduced from the analysis of the Segmentation by Silence events. Namely Sections 6 and 7 are related to each other, thus the previously noted similarity in contour between Section 1 and Section 7 then implies a relationship between Section 1 and Section 6. Similarly, the similarity between Section 1 and Section 5 also implies a relationship between Section 5 and Section 7. Then considering that there is a mirror reversal of the amount of complexity between Sections 4 and 5 similar to the relationship between 6 and 7, the implied relationship between Section 1 and Section 5, by extension further implies that there is also some relationship between Section 4 and Section 1. This suggests that, even though visually the relationships differ, there are logical structural relationships between all the sections.

This implies that the composer has a deliberate structural design of seven sections which underlies the changing arrangements of attribute combinations.

e. Implications of Attributes over the Time Domain

Event complexity is demonstrated both by the number of attributes which occur simultaneously in the qualitative listening observation for a sound event and also by those sound events which are Partially Indeterminate. Analysis showed an interlocking pattern between the Partially Indeterminate Events and the complexity contour of Attribute Combinations. It also shows that even though some regular patterns of even occurrence are set up over the first part of the music, these patterns break down in the final third of the music, where the most significant sequence of variations in complexity and attribute combinations.

Interestingly, the most common Transition Pairs occur only in the second half of the music. Each pair occurs twice before changing to the next Transition Pair. There are

two different patterns which each have three pairs at equidistant time intervals within each group, but different intervals in each group.

This implies that there is more variation among individual sound events in the first half of the music with less discernible emphasis on structure being audibly marked by these transitions.

f. Implications of the Time Domain at the Feature Set Level

Visual analysis of fuzzy feature sets in individual attributes across the time domain reveals a number of identifiable patterns over some portion of the music. Several attributes showed various component feature sets with varying trajectories which interacted to produce continually different results. The features in Amplitude grew louder over time. Feature sets of Texture would most often be active in only one part of the music, such as the first half or middle time span. In the other attributes, Register and Tempo, there are 'book-ending' events in one feature set of each attribute, but they occur at different time intervals ranging from 1'55" to 3'05".

Register moves in an arch form starting from Bass and moving back to Bass by the end of the music. Although there is a very quickly changing mass of sounds with variable Registers occurring between 8'40" and 11'15". Following these initial events there is a general tendency for the music to move towards the Very High Register two-thirds of the way through the music. However, this trajectory is not a linear smooth progression.

Pedal Tones occur early in the music until E14 at 4'40", Repeating Sounds mostly occur in the three-minute time interval mentioned previously, bounded by E27 at 8'20" and E41 at 11'15". It is difficult to see any other substantial patterns in Texture, apart from groups containing various combinations of feature sets. These groups arise visually through separation in the time domain, as well as the recurring appearance of various Multi-featured events which also visually breaks the events into groups.

Reflective Events change from one feature set to another and back again with no easily discernible trajectory. There is a time pattern of about 1'00" between some pairs of events within individual feature sets which is most obvious in the first half

of the music, but can still be discerned in places through the second half of the music. Other pairs of identical features appear to occur but are not as clearly defined, because they contain intervening Reflective Events in other feature sets.

Most Tempo events occur in the second half of the music in a pattern which resembles Register. There are fewer sound events classified in the attribute of Tempo, yet the time pattern of feature sets in Tempo is similar to the patterning of Register. The initial feature set of Rapid returns again at the end of the music in a mirror of the opening.

The Abductive Idea that Makes Sense of this Music

All the previous contemplations and analytical implications combine to suggest an idea as the foundation on which this music was composed. This principal idea uses all the information gathered during this personal experience of this music. I am not arguing that this idea is the correct interpretation, or that every listener will or should make sense of this music in this way, or that the composer intended to communicate this specific idea. Rather, this idea is one possible way to make sense of this music.

Potential Idea 1: Implications of the Title

There were no implications from the title before or after listening as it is in German, a language with which I am not familiar. I have no idea to what the title refers. I will be listening to this music without much guidance from the composer, or publisher.

Potential Idea 2: Immediate Impressions

Immediately after listening, only two clearly related events stood out in my mind, both single notes which fade away to silence. There was a distinct possibility that the music was sectional and that some sections never really got off the ground for some reason that was not really clear in the music itself.

All the immediate thoughts about this music were focussed on technical aspects, such as the continual variation of events, even though there was such self-referencing to other parts of the music. Textures varied widely, Register also varied widely as did Tempo, with most events being different in some way.

A significant aspect of this music is the speed at which new events and variations of events occurred. The variations occurred in diverse ways. Some features emerged or disappeared out of the music while other features continued. Sometimes a specific type of sound event would be repeated but varied in one attribute. In fact, it became clear that continuous variation was an important aspect of the composition.

Potential Idea 3: Logical Conclusions from Visual Analysis

The music can be seen as segmented into seven sections by the several clear Silence Events which occur at irregular times. As detailed previously, there are some visible and logical structural relationships between some of those Sections. Segmenting the work into sections shows that sections do not repeat material directly, even if there is embedded logical structural similarity.

An Abductive Interpretation: The Idea that Makes Sense of this Music

Immediately after listening, only two clearly related events stood out in my mind, both single notes which fade away to silence. However, these events are not identified as structural markers reinforced by relation to any other aspect of the unfolding of the music in the Time Domain, nor in relation to any other Events, beyond marking the end of their individual sections.

The key thing that strikes me about this music is its minimalism with respect to any conventional concepts in music. For example, there are melodic fragments of one or two notes, sometimes repeated, rather than complete phrases. The music itself is built on the repetition of materials, but with variation. Primarily, the idea seems to be the continual variation of Texture, through a broad range of possibilities. When particular Textures are repeated, the repetition is also accompanied by changes in Register, Tempo or Amplitude. Many times, there is an element of uncertainty about specific Textures as events emerge over time to form separate 'voices' then recede into the background. There are groups of directly repeating events, such as Pedal Tones, or Alternating Chords, but what becomes apparent through the analysis is that the duration of groups is variable.

This, in itself, indicates that the work is very much about continual variation within limited possibilities imposed by the solo piano being played in a conventional manner. The variation in this music arises through motivic and textural differences,

within the framework of conventional tempos and various conventional means of unfolding the 'voices' in the music such as arpeggiations, multi-note chords or melodic notes. What is unusual about this music is that it pushed all these conventional attributes to extremes. This is the main idea behind this music. A play of convention to see how far various conventional features of music can be extended individually and in combination before they collapse.

Appendix B. *Fuzzy IDEAS* applied to *Women in Transit* (Hope, 2004)

Women in Transit (Hope, 2004) is the music used in this worked example, which demonstrates how *Fuzzy IDEAS* works to discover possible ideas in this music along with the technical aspects of the music, which have stimulated those ideas. This worked example uses my own experience of listening to this music. The first section provides detail on the information collected prior to listening to the music about prior knowledge of the music and the impact of the title as a framework for listening. The second stage, which is not directly documented in the analysis, is the collection of the qualitative listening observations while listening to the music in real time, while the fourth stage provides details of any problems encountered in the collecting the qualitative listening observations, and details the qualitative listening observations collected for each Reflective and Partially Indeterminate Event. The intermediate stages of the conversion to fuzzy logic entities and the visual representations of the fuzzified data are worked through, until Stage 9 draws out the ideas implied by analysis of these visual representations, in conjunction with earlier conjectures which emerged in the previous Stages.

Stage 1. Documenting Pre-Listening Pre-Conceptions

The purpose is to identify what the listener brings to this particular listening experience. This section documents various aspects of mental preparation for the listening experience which will both affect and inform the actual experience of the music. This includes considering the possibilities suggested by the title for ideas in the music, along with any preconceptions brought to the listening experience through prior knowledge of the composer or the style of music.

The title clearly refers to women being in the process of change. The title is very specific with regard to gender. Hence it is probably not a piece of music written about people in general, such as refugees on the move, or tourists waiting in airports. The fact that the title is specific with regard to gender points to an awareness by the composer of the specific social and cultural implications of a specific identity.

The title is literally a statement about something material, external to the music, rather than something that points to the sound world which will be used to construct this music. However, the publisher, the Australasian Computer Music Association, is known for pushing the boundaries of what is generally considered to be 'music'. This strongly implies that the music is acousmatic, rather than a recording/documentation of human performers playing conventional instruments in a concert-like performance. Hence, there is a strong possibility that the sound sources for the work will be either sampled found sounds, or synthesised sounds. Yet the specific sound sources remain uncertain. Sampled sounds can arise from a vast array of possibilities ranging from bird calls to the sound of train wheels screeching around a curve in the railway tracks. It is also possible the sound sources are samples of conventional musical instruments possibly used in the unconventional ways made possible by digital processing and manipulation. The use of synthesisers in science fiction sound tracks, such as the theme for *Doctor Who*, has built an association between synthesisers and extra-terrestrial realities. Hence, this platform for presentation opens the possibility that this music will be 'other worldly'.

Although the title does not explicitly specify the form of the work, the idea of transition suggests the possibility of continual change, hence a through-composed piece of music.

Stage 2. Collecting the Qualitative Listening Observations

I used pencil and paper to document qualitative listening observations about the music or my self-aware subjective responses while the music is playing, along with time points at which those qualitative listening observations were made.

My experience of listening to *Women in Transit* produced 34 qualitative listening observations over 10'00".

Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience

The documentation of the listening experience concludes with an account of the immediate impact of the complete piece of music as a sense-making experience.

Because the actual music was constructed out of quickly changing, but clearly evolutionary, sounds, my attention was quite focused on the detail of the music, in an attempt to make sense of the sonic experience. Through the cymbal solo E18 at 5'00" (the central time point of this music) and the immediately following sound events such as feedback and the mike tapping sounds, the idea began to take shape that I was listening to a rock band ensemble, with added sounds which can arise accidentally from the amplification set up of an electric rock band. The two spoken voices, male and female, and flute are another significant variation from a typical 4-piece rock band.

Through punk and heavy metal music we have become accustomed to hearing heavy yet controlled distortion of instrumental sounds, and the replacement of melodious singing by speaking, shouting, or chanting. Yet, even in these genres the sound is 'clean'. There is no electronic circuit feedback or tapping on microphones or uncontrolled deformation of the sound. The performance I was listening to was increasingly being broken up by these types of 'dirty' noise. I concluded that this was an unedited real-time recording of a rock band in 'live' performance, working, at every opportunity, to break with expectations of what a rock band should do to sound polished.

Stage 4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations

Any problems arising while collecting the qualitative listening observations are documented here. This stage also provides the detailed qualitative listening observations which capture thoughts, reactions, memories, or images, that rise to conscious awareness in response to the sound of the music. These cognitive events may arise instead of, or as well as, any observations about technical aspects of the sound of the music.

I used a CD player for the listening test. This enabled the use of the digital timer on the CD player to determine the time points of the qualitative listening observations. Using a CD player also meant a fail-safe alert to the end of the music, in the absence of live performance cues, as the next track would eventually begin playing.

During listening it was difficult to find a consistent focus for attention, as many aspects of the music changed quite rapidly over short time spans. This attentional problem was exacerbated as there was nothing either in the title or at the start of the music on which to ground the actual experience of making sense of the music. There were many different types of sound events in the music, through variation. I began to wonder if I was listening too closely, that each sound event perhaps was not important, but rather their collective existence against which other things could contrast and thus be immediately highlighted in the listening experience: such as the cymbal solo, or the flute duet.

Rather, the piece slowly emerged into itself as the sounds accumulated. In fact, much of the music was a wash of sound, where individual things happen so quickly, which produced the overall effect of a sonic kaleidoscope, in which not much stands out except momentarily, as the wheel turns and the patterns change.

Ultimately, two series of events caught my attention. The first series generally occurred when there was a dramatic new type of event happening compared with what else was going on in the music, such as when Bass Guitar entered the music. This was a very distinct sound, because of its low register as well as being a clean, undistorted, guitar sound. Several other distinct events stood out from the general kaleidoscopic swirl of sound that was in place. For example, when several things coincided to make this event stand out from the background, even though the sound source was not identifiable. Firstly, there was the rise to conscious awareness of a pre-existing drone, but on top of this was the entry of a new, much louder sound in a different register. Another example is the complete Silence simply because this was such a contrast to the preceding material which had been so continuously evolutionary and 'noisy'.

Again the prolongation of the ride cymbal solo was distinctly different. This time the difference was because of the Texture and the Duration. There was no

accompaniment (it was a solo), and it was Sustained, whereas most of the other sound events were quite short. The second series of sounds arose from no obvious sound source: high pitched whistles, feedback, echoes, and distortion. Some sounds entered very quietly, masked by events more aurally dominant at the time. The prolonged events only became obvious and interesting focal points because they continued long enough to become part of my conscious awareness.

Table B.1 below, provides the listener's qualitative descriptions of cognitive events and any technical observations associated with those thoughts or insights. The precise details of each of these observations are usually quite different from one another. This documentation enables comparison of the qualitative listening observations not only within this particular analysis, but should the experiments be replicated, it enables comparison of whether and how other listeners have described similar events. Table B.1 does not list all the qualitative listening observations for the whole of this listener's experience. Rather Table B.1 only details those qualitative listening observations that contain cognitive processing associated with self-awareness of perception, memories and reactions to the sound of the music; moments of focused attention on the music; along with any moments at which the listener has become consciously aware that particular aspects of the sound of this music have stood out. In preparation for the 'fuzzification' of this information during Stage 5, in accordance with the rubric for the method, all documented time points are quantised downwards to the nearest five seconds.

Table B.1. *Women in Transit*: List of Cognitive Events

Event Number	Time	Event Description
E0	0'00"	Focus on the music with interest on its unfolding.
E1	0'15"	Awareness that a long high sound has been present for some un-specifiable amount of time continues, while another sound starts at this time point. The entry of this new sound draws my attention. The Sound Types for both sounds are Unclassifiable.
E2	0'40"	The Sound Type for this event is Unclassifiable, but the actual sound is the rattling that chains make as they are being folded and stored.
E3	0'55"	A voice starts but is so quiet it is indecipherable as to the text, and whether it is male or female.

Event Number	Time	Event Description
E4	1'20"	The Bass Guitar entry draws my attention.
E5	1'25"	The Sound Type for this event is Unclassifiable, but the actual sound is the radiophonic whistling that occurs while tuning analogue radios, or is produced by deep space telescopes when researching the cosmos.
E14	3'55"	This event is a Relative Silence, meaning that it is a noticeable pause in the unfolding of the sounds.
E16	4'15"	This Silence Event stood out in contrast to the preceding events, and so focussed my attention on itself.
E18	5'00"	This is a continuation of the previous event, which occurred because this prolonged solo for the cymbals stood out in the texture as being extremely unusual for its duration, and for being a solo in this quite densely textured music. This solo really attracted attention through its prolongation.
E19	5'20"	The previous cymbal solo was brought to a sudden end by a loud eruption of the flute.
E21	5'50"	The cymbal sounds return underneath the Flute motifs.
E23	6'30"	Guitar riffs occur as well as the continuing sound of microphone feedback. This was also the beginning of my thinking that this was a live recording of a rock band that was doing about everything to break with expectations of what a rock band should do to sound good, by breaking everything up and making a lot of extra dirty noise. Once I started to think this I began to attend to the music more closely to see if this might be correct.
E24	6'45"	Reflecting on my rock band hypothesis.
E25	6'55"	Reflecting on my rock band hypothesis.
E26	7'55"	Sounds like a Beethoven opening gesture, because there is an accompaniment with a very strongly accented melodic motif based on triadic/arpeggiated material. The motif was unified by its accentuation, and by the close juxtaposition of the events. Also the accompanying arpeggiations provided a background against which the accented material could be heard.

Event Number	Time	Event Description
E30	8'55"	Uncertainty regarding Homophony or Polyphony as before, but this time the accompaniment is rippling arpeggiation out of which irregular accented single notes stand out as possible melodic fragments. However, these notes are so embedded in the accompanying texture that they never completely take on a definite form of their own.
E31	9'10"	Continuation of E30, notable because these attributes and features have continued for quite some time.
E32	9'30"	Sounds like Philip Glass style minimalism: repetitive rippling arpeggiation with very slow, primarily consonant harmonic movement, by stepwise single notes as the arpeggiations continue over time.
E37	10'25"	This sequence of repeated mid-register notes sounds insistent.
E40	11'10"	Silence emerges through a slow fade out of the preceding material.
E42	12'10"	The Bass Line has stopped, although I had not been conscious of its earlier presence until its sudden absence.
E43	12'20"	Dead Silence, stark and noticeable because it was in such contrast to the preceding material which did not alter in any way before this Silence. I was completely unprepared for its occurrence.
E44	12'30"	Disparate motivic fragments over chords. Each fragment is discernibly and clearly separate from the others, but don't really turn into anything definite.
E46	13'20"	Took some time to realise that nothing else was going to happen, indeed that this was in fact the end of the piece.

Stage 5. Converting the Qualitative Listening Observations into Fuzzified Data.

The purpose of this stage is to use fuzzy logic principles to classify the qualitative listening observations into my hierarchy of fuzzified data by means of the coding taxonomy set out in Chapter 5. The coding taxonomy provides a consistent and systematic way of organising and categorising the qualitative listening observations into fuzzy logic entities. The resulting hierarchy of fuzzified data describes each qualitative listening observation at two different levels of detail: attributes and fuzzy feature sets. This stage also contains details of specific problems, if any, encountered in the conversion process for this specific music.

Converting the listening observations for this music into visual form highlights a particularly distinctive aspect of *Women in Transit*. Describing and classifying the sounds of this music immediately distinguishes this music from conventional instrumental music. Specifically, the need was to find appropriate labels for both attributes and feature sets which are inherently meaningful and yet make suitable distinctions among the strange and unusual sounds which occur in this music. It seems important to separate out the generating mechanism for the sound, the Sound Source, from the Sound Type. Sound Type is used here to refer to the shape (amplitude envelope) and qualities of timbre and resonance which combine to make particular sound colours. In conventional instrumental music describing the Sound Source also identifies the Sound Type. However, in this music it is always possible to aurally identify the Sound Type, even if difficult to describe succinctly in words, and at times nearly impossible to identify the generating mechanism, or Sound Source. The significance of the difference between the two aspects of the sound description has been captured by introducing an attribute called Sound Type. Some feature sets of this attribute have been labelled with conventional instrumental names, such as Flute, as this provides a succinct way of describing the Sound Type, yet others have been labelled with more unusual names, such as Rattling, which gives an approximation of the actual sound type, without identifying its source. In these cases where the sound source is indeterminate, these events have also been included in Partially Indeterminate Events, in the feature set of Uncertain Sound Source.

Once this distinction was made, the problem remained in deciding whether to label the feature sets of Sound Type into typical rock band higher level groupings such as Drum Kit, which would then include both cymbals and drums in the same fuzzy feature set, or to separate them at the lower level of individual sound types so that Cymbals and Drums would become separate feature sets. Each particular sound type occurred only a few times at irregular moments in the time domain, rather than occurring regularly and continuously throughout the music, such as a typical walking bass-guitar line, or drum pattern in standard rock music. Consequently, it seemed that each lower level sound type had its own significance and should be treated as an independent feature. This decision was reinforced by the need for quite detailed categorisation of those sounds which were not immediately classifiable, such as the whistling tone E1 at 0'15", or the rustling sounds E28 at 8'25". However, this degree of coverage requires ten feature sets within Sound Type. The fuzzy entities I selected for classifying technical attributes and features are shown in Table B.2. This table shows the technical details in the qualitative listening observations organised into attributes and then feature sets. This classification is designed to cover the sounds of this music in the most comprehensive yet efficient way. These attributes and feature sets will be used to represent this listening experience in visual form.

Table B.2. *Women in Transit*: Technical Attributes and Feature Sets

Attribute	Feature Sets		
Time	The smallest time interval between recorded events is 5"		
Amplitude	Loud	Very Soft	Dying Away
Register	High	Mid	
Event Duration	Long	Sustained	
Texture	Polyphony: interactive similar groups of sounds Homophony: two groups with some distinctive technical qualities Monophony: groups of single notes or chords of the same sound type Pedal Tones Alternating Sounds		

Attribute	Feature Sets		
	Repeating Sounds Single Sound Events		
Sound Type	Unclassifiable Electronica Rattling Sounds	Female Voice Male Voice Rhythm Guitar Bass Guitar	Flute Drums Cymbals

Stage 6. Constructing Visual Representations of the Fuzzified Data

The purpose of this stage is to report the fuzzified data in a visual format which directly represents various aspects of this personal experience of the music. The visual representations are constructed from the fuzzified data for each sound event at both attribute and feature set level. The quantisation interval selected for mapping the fuzzified data into the visual representations is based on the smallest time interval between the quantised time points, which here is five seconds.

The fuzzified data in time series at the attribute level gives the single most complete overview of the listening experience. This visual representation is provided in Figure B.1 below.

By contrast, the fuzzified data at the feature set level across time gives the most detailed visual representation of the listening experience. This level of detail requires multiple visual representations which are presented in Figures B.2-B.7 below.

a. Attribute Combinations across the Time Domain

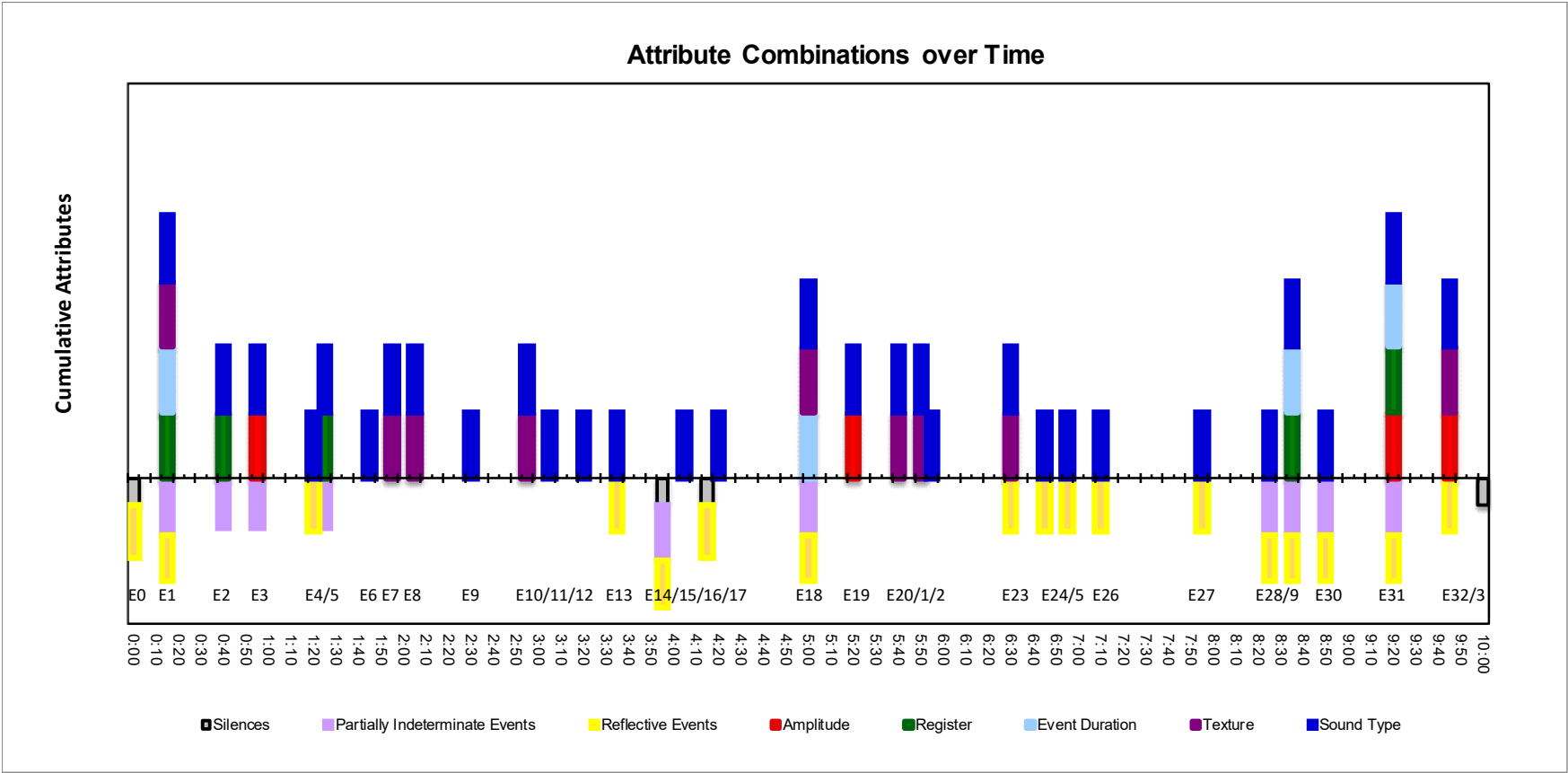


Figure B.1. *Women in Transit*: Attributes across the Time Domain

b. Fuzzy Feature Sets across the Time Domain

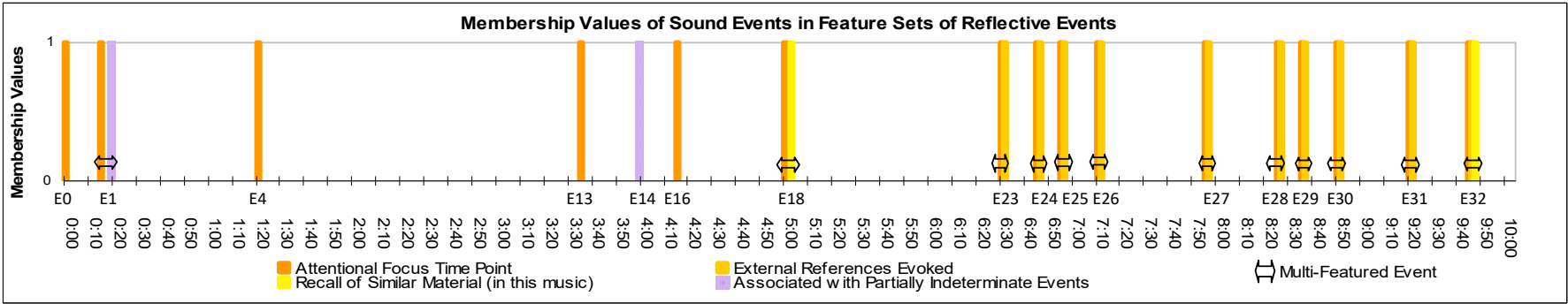


Figure B.2. *Women in Transit*: Feature Sets of Reflective Events over Time

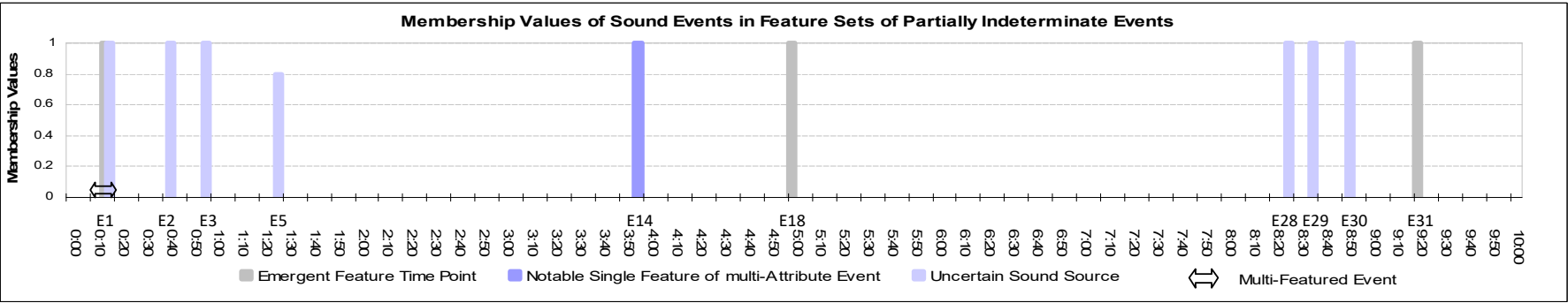


Figure B.3. *Women in Transit*: Feature Sets of Partially Indeterminate Events over Time

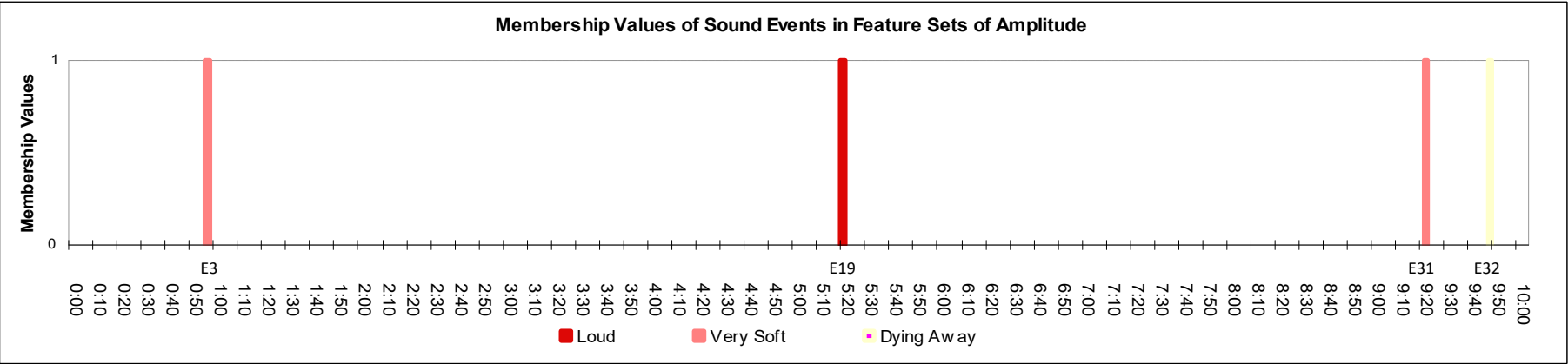


Figure B.4. *Women in Transit*: Feature Sets of Amplitude over Time

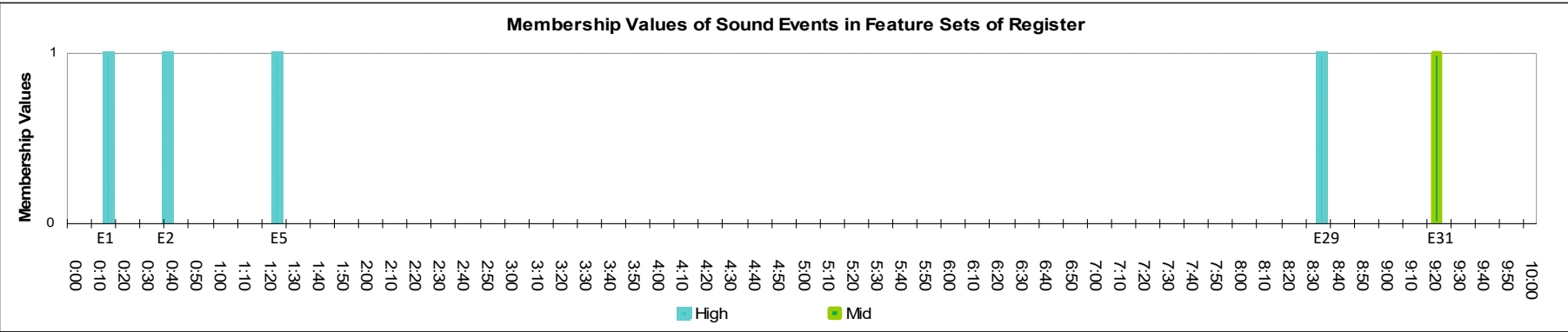


Figure B.5. *Women in Transit*: Feature Sets of Register over Time

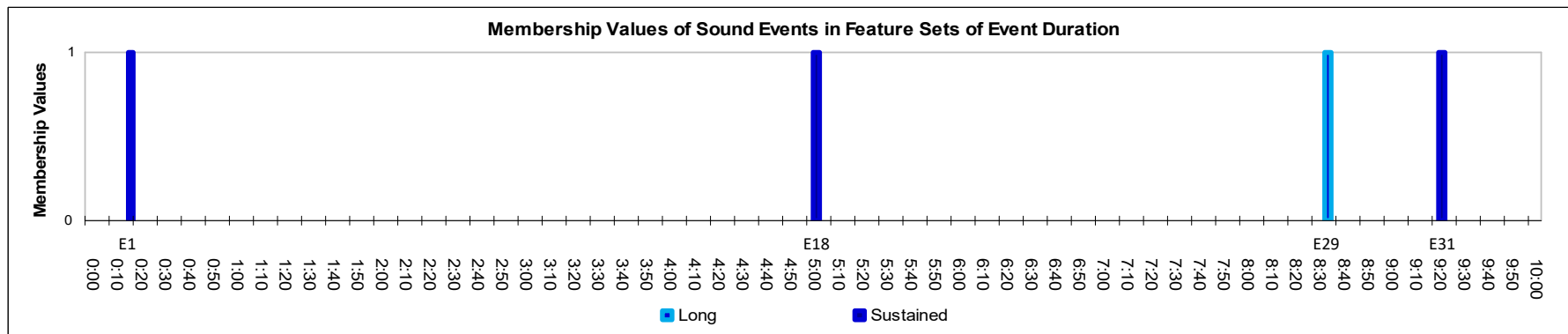


Figure B.6. *Women in Transit*: Feature Sets of Event Duration over Time

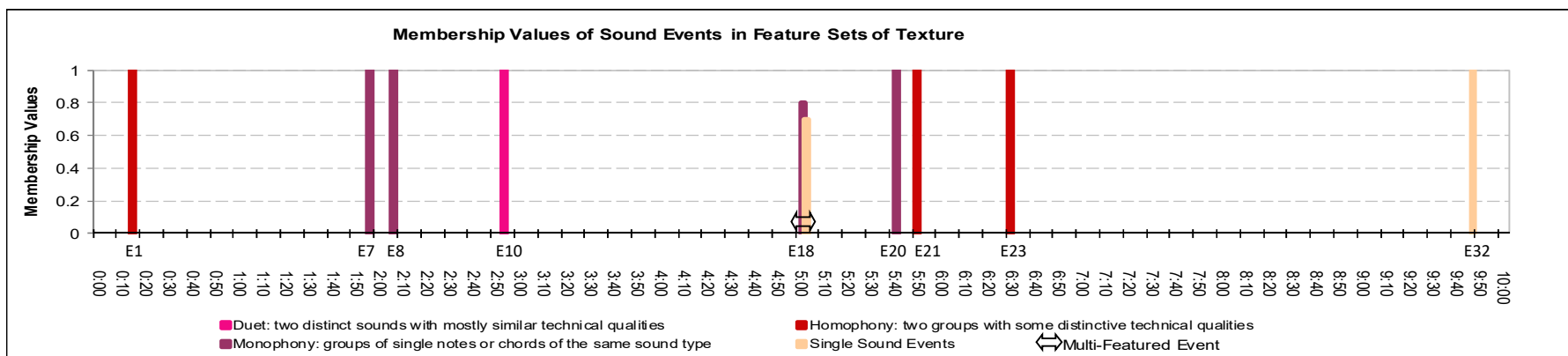


Figure B.7. *Women in Transit*: Feature Sets of Texture over Time

Stage 7. Analysing the Frequency of Fuzzy Entities in the Visual Representations

This stage summarises the information conveyed by the visual representations to draw out those attributes and features highlighted in this single experience of the music. These significant occurrences imply that these particular qualities have been emphasised by the composer. Relative frequency of attributes and feature sets also indicates the amount of variation between individual sound events.

a. Frequency of Attributes

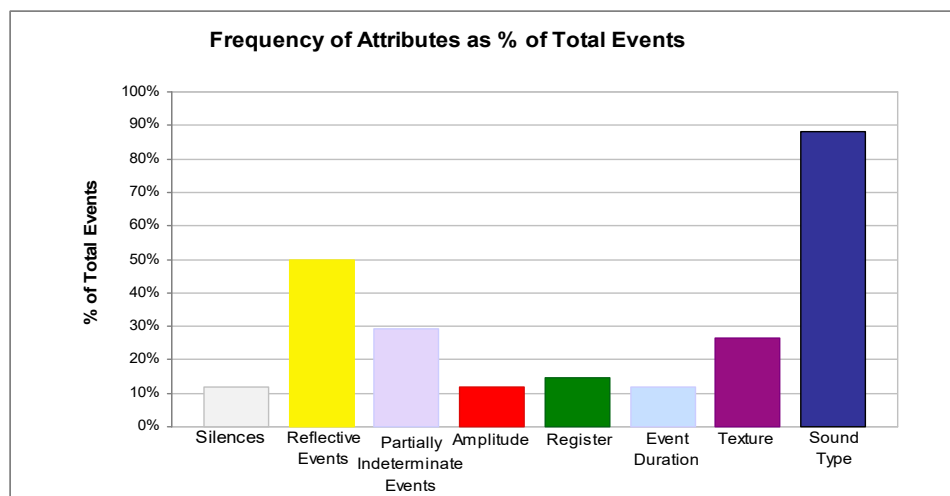


Figure B.8. *Women in Transit*: Frequency of Attributes

This experience of this music is described by eight attributes: five Technical attributes, Silences, and the two Cognitive attributes - Reflective Events and Partially Indeterminate Events.

This music has prompted Reflective Events for 50% of total events, while 29% of total events are Partially Indeterminate.

11% of total events are Silence Events.

By far the most common attribute is Sound Type, included in 88% of all events, while nine sound events (26% of total events) include Texture. Amplitude, Register, and Event Duration are each included in just over 10% of total events.

c. Frequency of Sound Events in Technical Feature Sets

Each attribute is broken down into its constituent fuzzy feature sets. Figure B.9. *Women in Transit*: Frequency of Technical Feature Sets below provides a set of histograms, each of which shows the proportion of total sound events included in each individual feature set within an attribute.

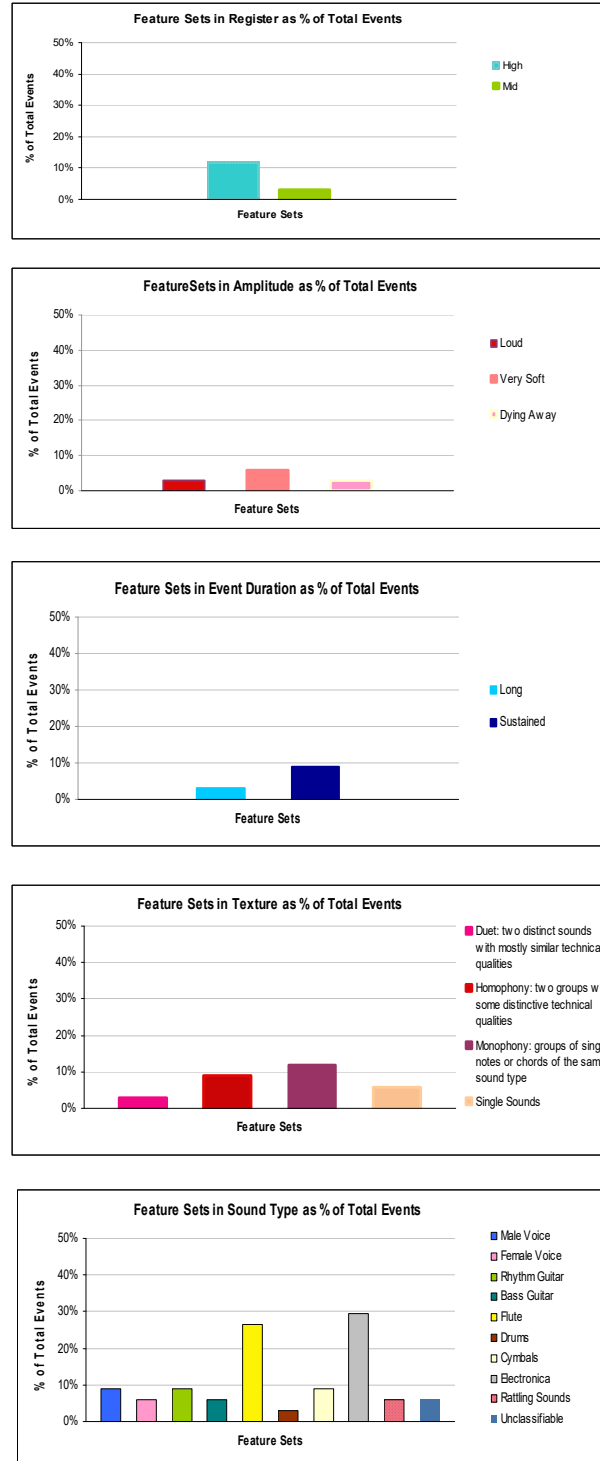


Figure B.9. *Women in Transit*: Frequency of Technical Feature Sets

Figure B.9. above reveals that by far the most dominating attribute is Sound Type. The feature sets of Sound Type have the highest proportion of total events categorised in any single feature set in any of the attributes. The feature sets with the highest number of members are Flute which has 26% of total events, and Electronica which has 29% of total events. The smallest is Drums which is observed only once.

Texture is also included in 26% of the total number of events. Texture is covered by only four fuzzy feature sets, of which Monophonic occurs 4 times, covering 11% of total events, while Homophonic (two voices each of which has a distinct character) has 3 events or 8% of total events. The smallest feature set is Duet which contains only 1 event.

Amplitude and Register are both relatively infrequent attributes, which is highlighted by the sparsity of feature sets in these attributes. However, Register contains four (11%) events in the fuzzy feature set of High. This means that this feature is equal in importance to some individual feature sets in more commonly occurring attributes. Although Event Duration appears relatively unremarkable with only two feature sets, three events (8% of total events) had a Sustained Duration.

d. Frequency of Feature Sets of Partially Indeterminate Events

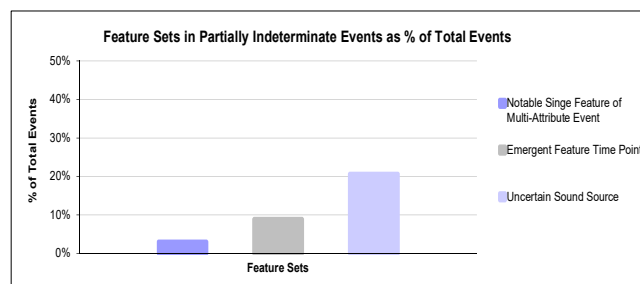


Figure B.10. *Women in Transit*: Frequency of Feature Sets in Partially Indeterminate Events

Partially Indeterminate Events which are included in 29% of total event descriptions. The highest ranking feature set is Uncertain Sound Source which includes 20% of individual event descriptions, which is one of the feature sets with the most events.

e. Frequency of Feature Sets of Reflective Events

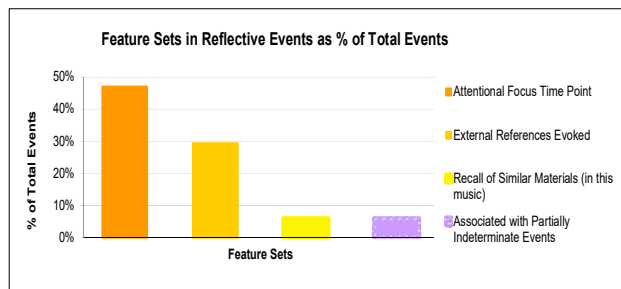


Figure B.11. *Women in Transit*: Frequency of Feature Sets in Reflective Events

The feature sets of Reflective Events have the highest proportion of events categorised in any single feature set in any of the attributes. Attentional Focus Time Points are documented for 47% of total events which are sound events which simply drew attention to themselves, while 29% have been categorised as External References Evoked.

f. Frequency of Attribute Combinations

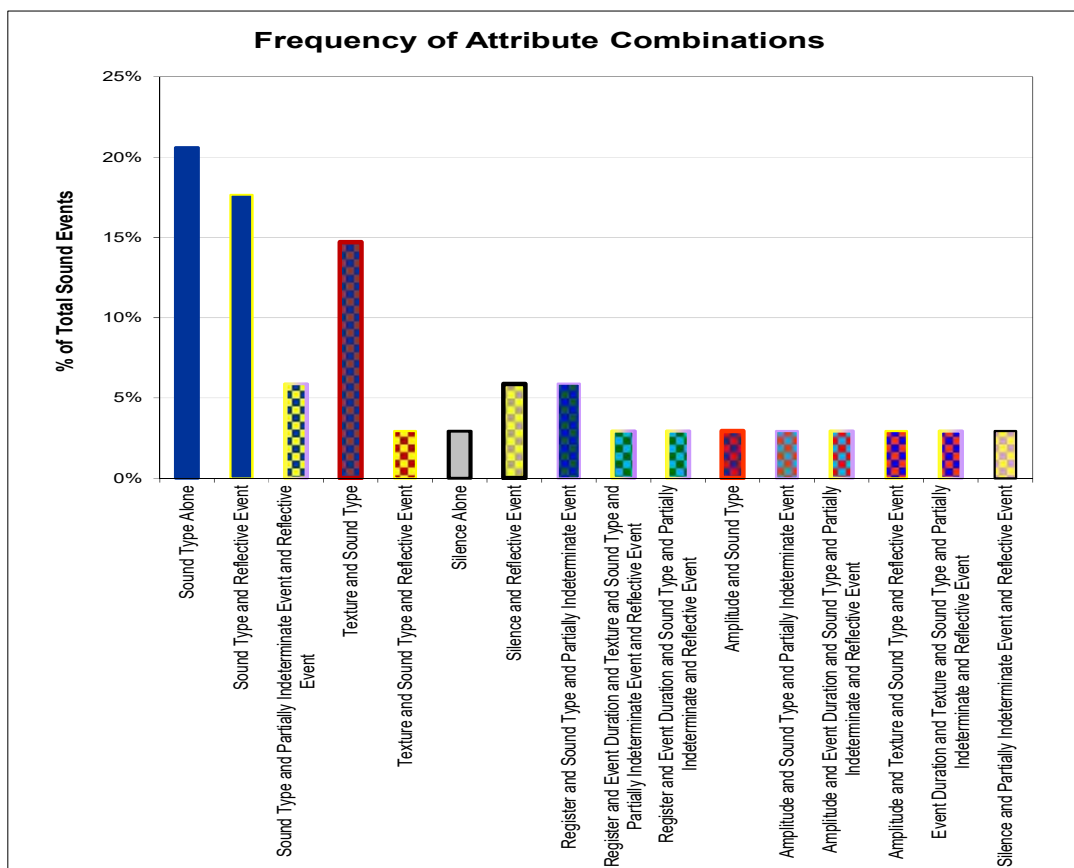


Figure B.12. *Women in Transit*: Frequency of Attribute Combinations

The Frequency Distribution of Attribute Combinations shows the most and least common combinations of attributes, as well as the similarity between all events at the attribute level.

In *Women in Transit* the most complex events could have a maximum of five technical attributes excluding Reflective Events, Partially Indeterminate Events and Silences. In *Women in Transit* the most complex events have four technical attributes excluding cognitive attributes. Most events have more complexity than simply identification of the Sound Type, although 20% of total events had only one attribute: Sound Type Alone, while Reflective Events plus Sound Type covers 17% of total events. Texture and Sound Type as a combination occur five times during the music, which accounts for 14% of total events. Interestingly in this music, two of the Silence events are among the most frequently occurring combinations in this music, due to the uncertainty regarding their reason for occurring in the music at that time. Many Attribute Combinations only occur once throughout the music.

g. Frequency of Transition Pairs

Table B.3 shows only the duplicated Transition Pairs for this music. Transition Pairs that only occur once are not included in this table. This table is result of a comprehensive comparison of all attributes between adjacent sound events across multiple attributes. Cognitive Events, including Reflective Events and Partially Indeterminate Events are included in these Transition Pairs.

Table B.3. *Women in Transit*: Repeated Transition Pairs at Attribute Level

Attributes of First Event	Attributes of Adjacent Event	Event Pairs	Number Identical Pairs	% of Total Transition Pairs
Texture and Sound Type	Sound Type Alone	E8-E9 E10-E11 E21-E22	3	9%
Reflective Event and Sound Type	Reflective Event and Sound Type	E24-E25 E25-E26 E26-E27	3	9%
Sound Type Alone	Texture and Sound Type	E6-E7 E9-E10	2	6%
Texture and Sound Type	Texture and Sound Type	E7-E8 E20-E21	2	6%

Reflective Events are included in one or both sound events in 22 (66%) of Transition Pairs, while 15 (45%) Transition Pairs include a Partially Indeterminate Event. The two most common Transition Pairs occur three times throughout the whole of the music. Three attribute-identical Transition Pairs of Reflective Events plus Sound Type are matched in frequency by three Transition Pairs from Texture and Sound Type to Sound Type Alone. Interestingly, this is a similar pattern to the next most frequent Transition Pairs. Two attribute-identical Transition Pairs, Texture plus Sound Type, are matched by two Transition Pairs between Sound Type Alone to Texture plus Sound Type.

In *Women in Transit*, none of the events in immediately preceding the four Silence events are identical in terms of attribute combinations. The sound event which occurs immediately before the final Silence of the whole piece is one of the more complex events in the music as it contains three attributes. It is certainly the most complex event which immediately precedes any of the Silence events.

Stage 8. Analysing the Time Structure of the Visual Representations

The second type of analysis on the fuzzified data explicitly focusses on visual analysis of the time-patterning of attributes, features, and Silence events. This is achieved by constructing a set of analytical charts from the time point visual representations. Each analytical chart addresses a single aspect of the time point representations of the fuzzified data.

a. Time Structure of Attributes of Silence Events

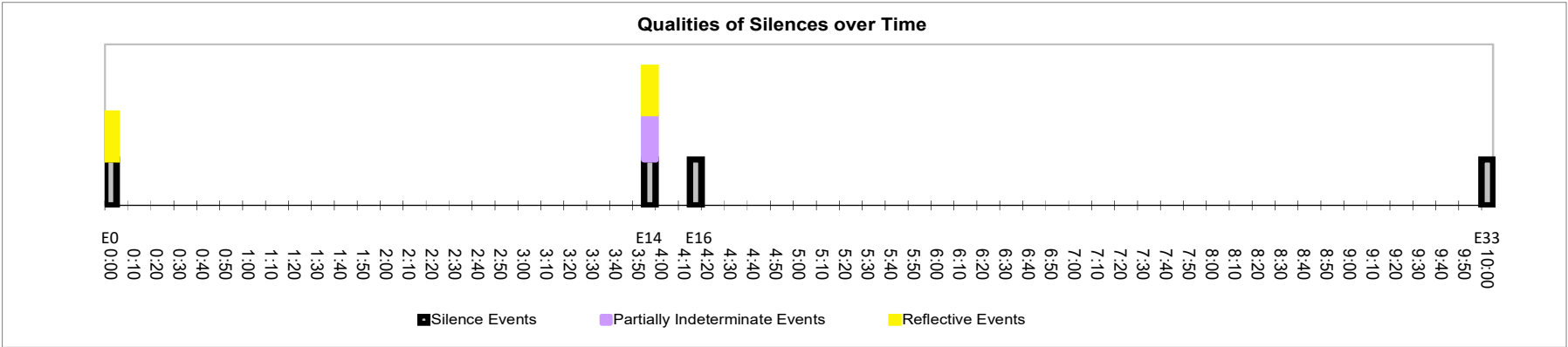


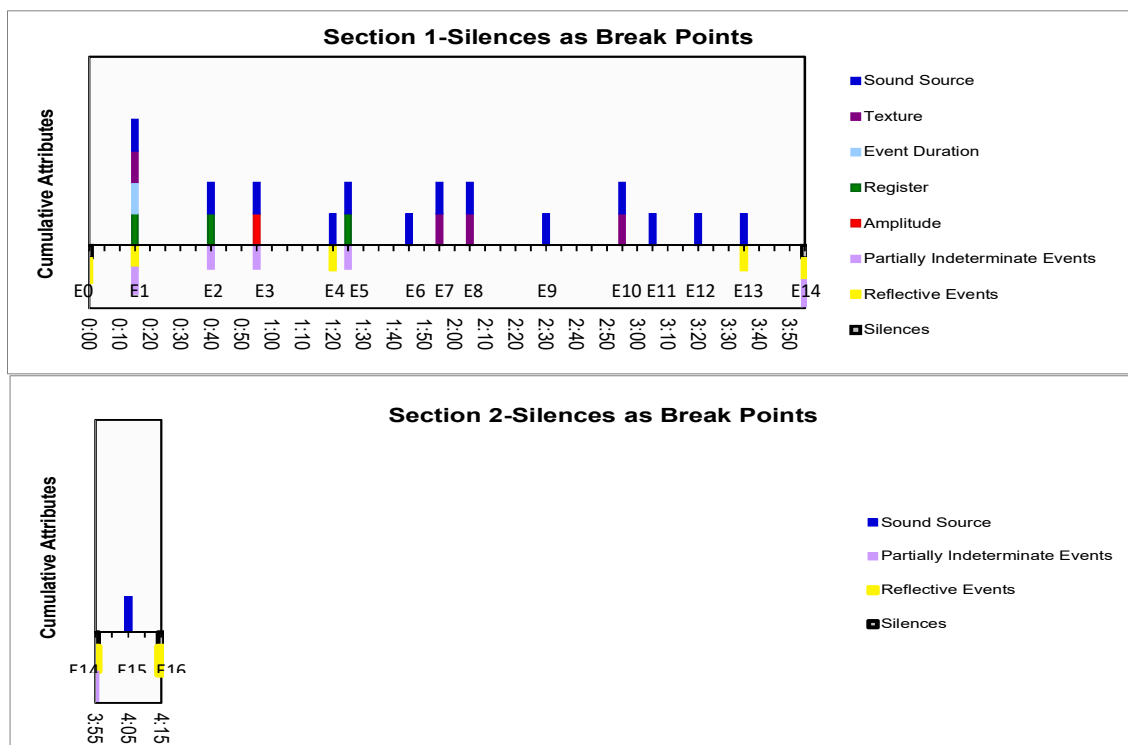
Figure B.13. *Women in Transit*: Silences and their qualities over Time

Figure B.13 above maps the Silence Events over time. What this chart shows is that not all Silence Events are the same. Some are uncertain because it is not possible to know at the time of hearing, what this absence of sound implies. Possibilities range from the end of a section, or the end of the entire piece of music. Alternatively, the previous sound event has such a diminution in amplitude that it is not possible to be fully cognisant of when the Silence actually started. These types of Silence Events can also generate Reflective Events as the listener attempts to make sense of each Silence Event as it occurs.

The four documented Silence Events show a lop-sided distribution over the time domain of the music. Most of them occur prior to the central time point, in the first half of the music, with associated Reflective Events. The second half of the music is clearly documented as continuous sound. However, this music is marked by a clear unambiguous Silence Event to conclude the music..

b. Sectional Segmentation by Silence Events

This part of the analysis explores the sectional structure where the duration of each section is determined by the timing of Silence Events. The overall duration of each section and the attributes of events in each section are shown in Figure B.14 below.



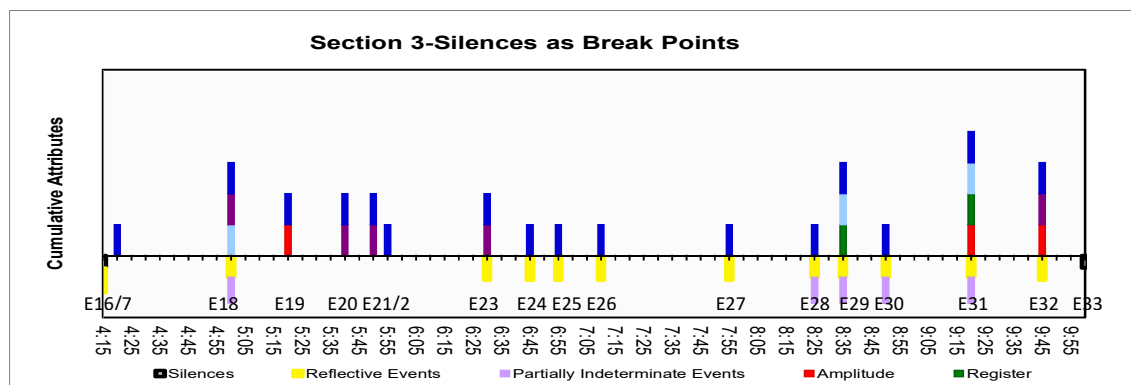


Figure B.14. *Women in Transit*: Segmentation using Silence Events as Break Points

The most obvious thing to emerge from the segmentation is that this music contains three sections of very different length. The first section is nearly four minutes long, compared with the final section which is nearly six minutes long. The middle section is very short, at 20 seconds, and contains only one sound event. However, Section 2 most resembles the straightforward ending of Section 1, hence it could be thought of as some type of reprise, or second ending, of Section 1. The major sections of the music seem to be the inverse of each other, so that the music starts and ends with the most complex events.

There is a strong visual resemblance between the opening of Section 1 and the opening of Section 3. Although the initial sound events of both sections are quite different, the first complex event of Section 3 contains quite similar combinations of attributes as the first sound event of Section 1. From there the two sections seem to be the inverse of each other in terms of complexity. Where Section 1 has single-attribute events, Section 3 has more complex events, and vice versa. Section 3 and the whole piece, concludes with several complex events containing five and three attributes respectively. This places them, along with the opening events in Section 1, among the most complex events in the whole piece.

Rather than comparing each individual sound event across sections, it is interesting to consider the visual contour, or envelope, of event complexity. This envelope is the horizon traced over time by the height of each sound event at each time point. This visual inspection shows that the contour of Section 1 is repeated quite closely in Section 3 over a very similar time interval of approximately four minutes. It starts with events that are more complex and concludes with less complex events. Then

Section 3 is extended beyond the duration of Section 1 by the series of highly complex events leading to the conclusion of the piece. There is no doubt that the music has concluded by the time of the final Silence Event.

c. Event Complexity over Time

This section shows where both the most complex events and the most simple events lie on the Time Domain. Figure B.15 below summarises Figure B.1. Attribute Combinations over Time to show those sound events which have the most and the least technical attributes, i.e. those attributes apart from Reflective Events and Partially Indeterminate Events. Figure B.16 below summarises the configuration of Partially Indeterminate Events, to show the distribution and amount of uncertainty over time. These events contain some uncertainty regarding their definition, in both senses of the word: boundaries are vague, or there is difficulty with sound source identification. Partially Indeterminate Events are by definition more complex than other sound events because of this uncertainty.

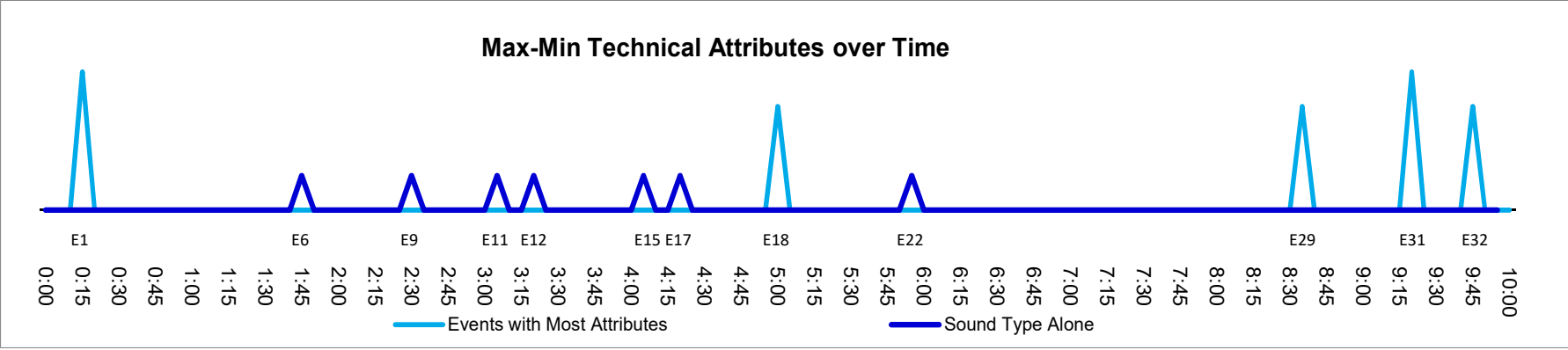


Figure B.15. *Women in Transit*: Max-Min Technical Attributes across Time

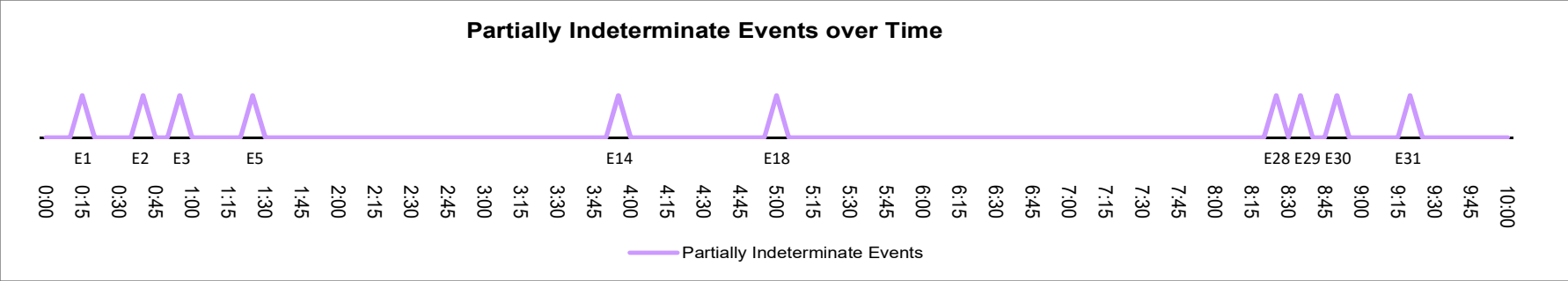


Figure B.16. *Women in Transit*: Partially Indeterminate Events across Time

Figure B.15 above summarises Figure B.1. Attribute Combinations over Time. This shows that the music is divided into two fuzzily equal parts by the complex events with the most attributes. The most complex events in *Women in Transit* have either three or four technical attributes, while the least complex events have only one attribute, namely Sound Type. Interestingly, these single-attribute events predominantly occur in the first half of the music. Most events in the second half have more attributes than only identification of Sound Type. However, most of the complex events occur in the final 1'30" of the music.

Figure B.16 above summarises the previous Figure *Women in Transit: Feature Sets of Partially Indeterminate Events over Time*. There is a visual pattern in this analytical chart. Partially Indeterminate Events serve to outline the beginning and the end of the music, over a time interval of 1'10", with another pair of Partially Indeterminate Events at the same time interval at the conclusion of the first half of the music. This pair of Partially Indeterminate Events includes E18 at the central time point.

These two charts display the two different dimensions of documented complexity and documented uncertainty. Both show quite similar temporal designs to the extent that both are focussed around the beginning, middle and end of the music in the time domain.

d. Most Common Attribute Combinations over Time

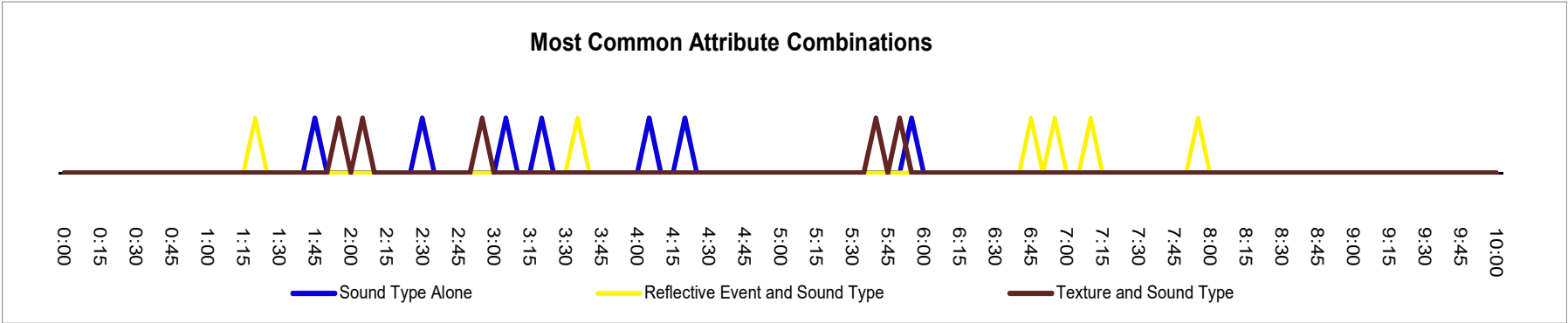


Figure B.17. *Women in Transit*: Most Common Attribute Combinations across Time

The music as a whole is examined for the time points of the Most Common Attribute Combinations, looking for obvious replications of sound events with identical attribute combinations across the time domain. This analytical chart includes all attributes, cognitive as well as the technical attributes. This is different than the previous analysis of the contour of technical complexity, because it places cognitive events on an equal footing with any technical attribute(s). For some listeners, cognitive events may be their primary way of responding while listening to the music. In these instances, this analytical chart allows that information to rise to the surface. Overall, this analytical chart provides information on whether and when specific sound events with identical components are repeated. This information can imply repetition or variation as the music unfolds which gives another insight into possible formal structures such as Rondo, where the opening theme is repeated several times after interjected alternate sections.

Figure B.17. *Women in Transit*: Most Common Attribute Combinations across Time above shows that Sound Type Alone primarily occurs in the first half of the music, while Sound Type plus Texture occurs primarily in the first two-thirds of the music, while Sound Type combined with Reflective Events occurs primarily in the second half of the music.

Additionally there is a clear temporal patterning which shows intervals of time longer than one minute where none of these frequent combinations occurs. These time intervals are at both beginning and end of the music, as well as the one minute space centred around the central time point of 5'00.

e. Repeated Transition Pairs at Attribute Level

Figure *Women in Transit*: Repeated Transition Pairs across Time below shows the timing of the duplicated Transition Pairs for this music.

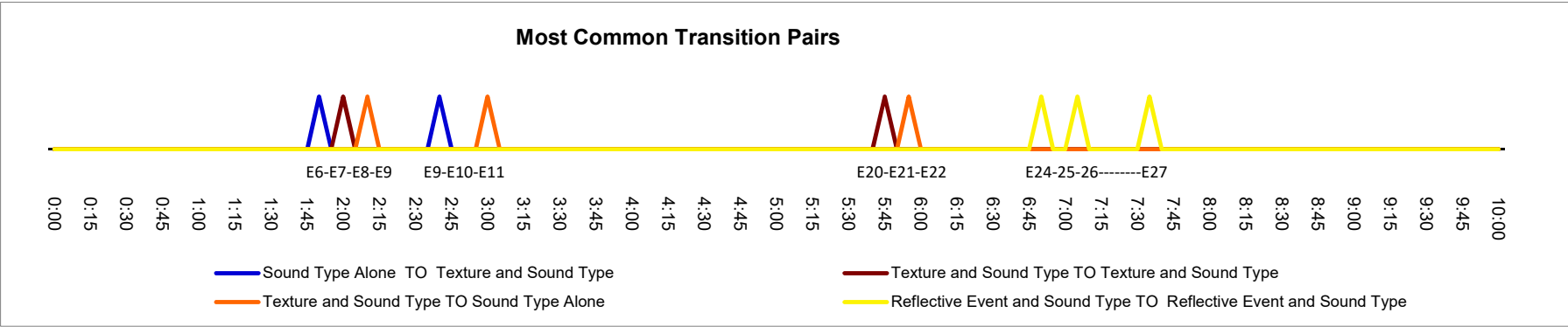


Figure B.18. *Women in Transit*: Repeated Transition Pairs across Time

Interestingly the Transition Pairs between Sound Type Alone and either itself, or with Texture added primarily occur in the first 1/3rd of the music, with a brief reprise approaching the 2/3rds mark. In contrast, all the transitions between the Reflective Events plus Sound Type all clearly occur in the last third of the music.

f. Time Structure of Feature Sets

This is an overview of the set of visual representations presented in Stage 6.

The temporal distribution of features within all the attributes, including those with relatively few events such as Amplitude, Register and Event Duration, serves to underline that the music is in two halves. The temporal distribution of attributes shows that the start and end of the music often have mirror events at those times, as well something either identical or very different occurring at the central time point. Those attributes which do not have this type of mirroring clearly have one or more Features highlighted in the first segment of the music which give way to other Features later in the music. In conclusion, the temporal distribution of features shows that the music is clearly in two halves, although two distinct processes occur simultaneously. Some features in Partially Indeterminate Events, Amplitude, Register, and Event Duration are mirrored around the central time point at 5'00". By comparison, Texture tends to repeat itself in the two halves, while others show gradual change as the music unfolds.

Stage 9. An Abductive Interpretation: The Idea that Makes Sense of this Experience

This stage draws out the overall key idea suggested by this experience of the music, and what this experience suggests about the compositional design. These abductive conclusions follow through on earlier hypotheses formulated immediately before listening presented in Stage 1, and immediately after listening presented in Stage 3, as well as the implications of the analyses presented in Stages 7 and 8. Here, in Stage 9, this synthesis links the technical features observed during listening and the previous hypotheses, to draw conclusions about the idea that makes sense of this experience.

a. Implications of Frequency of Technical Attributes, Attribute Combinations, and Feature Sets

The dominant attributes and features suggest that these sonic qualities have been emphasised by the composer, while the frequency of occurrence of sound events and the range of feature sets indicate the amount of variation between sound events.

The main attributes present in this music are Sound Type, Partially Indeterminate Events, and Texture, while Amplitude, Register and Event Duration are relatively insignificant as each only contain about 10% of total sound events in this music. Even though some attributes have low total numbers of events, some individual feature sets in these attributes can still contain as many events as the smaller feature sets in the more populated attributes.

All events in this music, except Silence events, are included in the attribute of Sound Type, while the next most frequent attributes are Texture, which includes nine (26% of total) sound events, and eight (23% of total) sound events which are Partially Indeterminate. This indicates that Sound Type is a particularly significant attribute to specifically characterise this music. The feature sets in Sound Type with the highest number of members are Electronica which is contained in 29% of total events, and Flute, which is included in 26% of total events. Hence these feature sets of Sound Type are more frequent than any other technical attribute. The smallest is Drums, which is observed at only one event E11 at 3'05".

The series of Sound Types described by the fuzzy feature sets of Electronica, Rattling, and Unclassifiable Sounds, would not have been present in normal rock performance as they usually represent errors in production. The presence of these materials suggests that the idea of this music is about challenging established conventions.

Texture became quite a memorable attribute of the music about halfway through the listening experience when the long Cymbal solo became a major feature in the time centre of the music. The other solo instrument was the Flute, which provided a strong contrast as a tuned melodic instrument compared with unpitched percussive sound of the Cymbals. Although the Texture was rarely complex, these solos stood out for their simplicity, and their relative timing. For these reasons, during the

analysis, the solos took on a lot of significance as a representation of something that was going along quite smoothly (Flute solo), then being challenged by prolonged noisy crashing sounds, even though quite rhythmic (Cymbal solo). This helped to set up the sense that this music was about undoing and challenging the status quo, whether of individual sanity under intense pressure, or the collective impact of woman striving for true equality disturbing the previous relatively calm and restful atmosphere.

Ten of the 34 sound events (29%) include Partially Indeterminate Events. 20% of total events contain an Uncertain Sound Source, which is the most common feature set in this attribute. At the beginning of the music, where even the specific sound source was sometimes Unclassifiable. Also included in Uncertain Sound Source are those initial sound events which contained unusual electronic interference such as distortion or feedback. However, once that aspect of the sound became normalised, there was little uncertainty about specific events which occurred later in the music.

Emergent Features are documented for 8% of total events. Some of these events are sounds which entered very quietly, only becoming obvious because of their prolongation, with no clear starting time. These sounds became, and were documented as, sound events because they continued long enough to become part of my conscious noticing.

In summary, analysis of Partially Indeterminate Events reveals how much uncertainty occurred during the listening experience regarding the nature and purpose of individual sound events, although this uncertainty gradually diminished as the piece of music unfolded over time as sounds became normalized and a tentative idea grew more possible as the sounds and reflections accumulated. Despite this growing certainty of the idea behind the music, towards the end of the music the uncertainty about sound source grew stronger again as the types of sounds changed so that again it was difficult to identify the source of the individual sounds.

There are ten recurring Transition Pairs which do not include Silences (39% of total Transition Pairs). Of these recurring Transition Pairs, eight Transition Pairs are attribute-identical. The recurring Transition Pairs as a group highlight events which

are focussed on Sound Type Alone which occur in one, either or both events of five recurring Transition Pairs; Texture is a recurring attribute along with Sound Type in seven events among the recurring Transition Pairs; while three events contain Reflective Events plus Sound Type in one of the events in recurring Transition Pairs.

Partially Indeterminate Events are included in 15 (45%) Transition Pairs. The Transition Pairs that do recur are primarily attribute-identical while most of the Transition Pairs include uniquely defining combination of attributes, so are individually different. Every Transition Pair which includes Silence events is different. This provides more evidence for the major idea of this music being about a process of gradual evolutionary change.

b. Implications of the Uncertainty Experienced by this Listener

Uncertainty is suggested by various aspects of the results. It is reflected by the number of Multi-featured events; the number and types of Partially Indeterminate Events; and the qualities of the Silence Events.

Multi-featured events denote the ambiguous nature of individual sound events that contain elements pertinent to several feature sets in the same attribute. Partially Indeterminate Events by definition denote events with uncertain boundaries, whether in the time domain or the technical description.

In this experience of the music, nearly half the sound events in Reflective Events are Multi-featured events. Although Multi-featured events occur in other attributes they are not as frequent.

Nearly 1 in 3 sound events across all attributes are classified as Partially Indeterminate Events. Notable Single Feature of multi-attribute event is included in 1 in 5 individual event descriptions. Emergent Feature Time Points occur only three times in this listening experience.

Half of the Silence events have additional attributes. This implies that there the composer has generated a sense of uncertainty regarding the convention that significant Silences mark the end of the music.

The large total number of events and need for ten feature sets in Sound Type shows that type of sound in each event is particularly relevant in this experience of this music. This implies that this is the main source of variation within this music.

c. Implications of Reflective Events

Reflective Events are part of nearly every sound event, of which 50% are Attentional Focus Time Points. Reflective Events are included in four feature sets. None of the Reflective Events have been classified as Free Range Thoughts. This implies that the sound of the music was quite attention-grabbing and stimulated a lot of other conscious thoughts. However, these thoughts are focussed around and on the sound of the music, rather than being free-floating images or memories.

d. Implications of the Time Domain: Silences as Break Points

Although the music has three sections defined by the occurrence of Silence events, the very short central section occurs well before the central time point. This section occurs by analytical definition rather than by any particular aural distinctiveness. Yet the combination of new sound sources being introduced throughout the music, and the combination of both conventional sounding rock riffs, with unusual electronic distortions, tends to cover over this careful temporal design to produce music which is in a continual state of change.

e. Implications of Attributes over the Time Domain

The temporal distribution of events shows that the music is in two halves, but that there seem to be two different processes in place. The first process is a mirroring around the central time point, highlighted by time domain analysis of event complexity, in that highly complex events occur at beginning, centre and end of the music. Figure B.15. *Women in Transit*: Max-Min Technical Attributes across Time shows clearly that the music is divided into two equal parts by the complex events with the most attributes. This division into two equal parts is reinforced by the temporal distribution of the Most Commonly Occurring Attribute Combinations: the relatively simple two-attribute combinations. These show a clear reversal of the former temporal patterning as these frequent combinations occur in the middle of each half of the music, rather than at the beginning and end of the music, or around the central time point at 5'00". The patterning of Register is weighted towards both

ends of the music, while being largely absent for a large part of the music between these bookends. This temporal pattern of mirroring is reinforced by the distribution of features within the attributes of Partially Indeterminate Events, Amplitude, Register and Event Duration.

Although Partially Indeterminate Events are more frequent in the first half of the music, yet the group of Partially Indeterminate Events at the beginning and end of the music form a mirror image around the central time point. The events which contain features of Amplitude also mirror over the course of the music, but around its own centre which is slightly later than the central time point of the music. Event Duration combines aspects of the temporal distribution of Amplitude, in that it mirrors and is weighted towards the ends of the music.

The second process is a more subtle evolution over the course of the music so that the end of the music contains more noted features than the beginning or the middle of the music. This is followed by the rate of occurrence of Reflective Events which shows a gradual evolution in this music. Reflective Events are more frequent in the final third of the music. Single-Attribute events occur slightly more frequently in the first half of the music. Analysis of replicated Attribute combinations also shows variation in the actual Attributes within the repeated combinations over the course of the music. Sound Type and Texture occurs primarily in the first half of the music, while Sound Type and Reflective Events occurs primarily in the second half of the music.

This evolution is also demonstrated by the temporal occurrence of Attribute-identical Transition Pairs. In total, 30% (10) of pair-wise transitions are Attribute-identical, while specific Attribute-identical Transition Pairs occur only two or three times. Yet, overall, the temporal distribution of Transition Pairs shows a change from the first half to the second half of the music. Texture is significant in the first half, while Reflective Events are significant in the second half. Sound Type is continuously present throughout.

f. Implications of the Time Domain at the Feature Set Level

Visual analysis of fuzzy feature sets in individual attributes across the time domain reveals a number of identifiable patterns over some portion of the music. The shift

in event density towards the conclusion of the music occurs as the features of various attributes unfold over time in various independent patterns. For instance, analysis reveals that Texture, rather than being a mirror or evolutionary, has a temporal distribution of features in the second half which repeat the pattern established in the first half. By contrast, the conversion from listening observations to graphic form reveals the interleaving of two series of events in Sound Type. The first series is conventional Sound Types. The first series consists of the entry points of those distinctive yet conventional instrumental sounds, so clearly and distinctly that their entry alone commands attention. The first series occurs as follows: E1 at 0'15" where a new instrument enters while a prolonged drone continues, E4 at 1'20" where Bass Guitar begins, the Silence event E16 at 4'15", a prolonged Cymbal solo E18 at 5'00", and another Bass Guitar entry E26 at 7'10". This series fades away over the course of the music, to be overtaken by the second series of unusual sounds which dominates until the end of the music. The second series is Electronica, Rattling, and Unclassifiable Sounds which in normal rock band performance would have not been present as they usually represent errors in production. These unusual sounds bookend the music but are most dominant from E28 at 8'25" through to the end. This second series contains E2 at 0'40", E5 at 1'25", E12 at 3'20", E22 at 5'55", E28 at 8'25", E29 at 8'35", E30 at 8'50", and E32 at 9'45". Thus, overall, Sound Types shows an evolutionary variation as the music progresses over time, so that for instance, Flute is gradually replaced by Cymbals is replaced by Electronica.

The Abductive Idea that Makes Sense of this Music

All the previous contemplations and analytical implications combine to suggest an idea as the foundation on which this music was composed. This principal idea uses all the information gathered during this personal experience of this music. I am not arguing that this idea is the correct interpretation, or that every listener will or should make sense of this music in this way, or that the composer intended to communicate this specific idea. Rather, this idea is one possible way to make sense of this music.

Potential Idea 1: Implications of the Title

The title clearly refers to women being in the process of change. The title is very specific with regard to gender. Hence it is probably not a piece of music written about people in general, such as refugees on the move, or tourists waiting in airports. The fact that the title is specific with regard to gender points to an awareness by the composer of the specific social and cultural implications of a specific identity.

The title is literally a statement about something material, external to the music, rather than something that points to the sound world which will be used to construct this music. Although the title does not explicitly specify the form of the work, the idea of transition suggests the possibility of continual change, hence a through-composed piece of music.

Potential Idea 2: Immediate Impressions

I concluded that this was an unedited real-time recording of a rock band in 'live' performance, working, at every opportunity, to break with expectations of what a rock band should do to sound polished. Through punk and heavy metal music we have become accustomed to hearing heavy yet controlled distortion of instrumental sounds, and the replacement of melodious singing by speaking, shouting, or chanting. Yet, even in these genres the sound is 'clean'. There is no electronic circuit feedback or tapping on microphones or uncontrolled deformation of the sound. The sound of the music was increasingly being broken up by these types of 'dirty' noise.

Potential Idea 3: Logical Conclusions from Visual Analysis

This analysis suggests that this music is about transition through a carefully planned trajectory, with occasional obstacles or interference, as shown by the placement of events with specific Attributes and Features in a way which continually demands attention, while actually revealing a kind of arch-shape structure in the use of the materials. The use of unusual sounds and the very low amount of direct repetition ensures that most events are variations on previous events, or contain something completely new. This is done in a way that builds onto what has occurred previously. Earlier materials do return briefly toward the end of the music, but are now subsumed into the greater quantity of new material built up during the

intervening time period. The form is very different from the conventional verse-bridge-chorus style of rock music.

An Abductive Interpretation: The Idea that Makes Sense of this Music

Feminism has influenced the expectations of, opportunities for, and put pressures on women to live and work differently from previous generations. Perhaps this idea is represented by the unusual distortion and distorted sounds as signs of stress and strain. Yet, this idea is projected by the music in a very abstract way, only revealed by analysis and conscious reflection on the form and content of the music. The actual sonic materials are firmly placed in the aural domain of rock music, rather than direct representations of women's traditional work.

The form and content of the music clearly support the idea of breaking stereotyped conventional behaviour. What I heard in this music was a reversal of the norms of a rock band in live performance. However, analysis using *Fuzzy IDEAS* reveals a much deeper idea being projected through this music. Specifically, the idea of women under pressure to live and act differently, to break out of traditional stereotyped roles. This conclusion can be drawn from the following aspects of the music itself.

Form and content of this music are about breaking with conventional behaviour. The actual sounds from which the music is composed challenge the traditions of a rock band in live performance. Unusually, the major solo is by the ride cymbal. There is also a series of distortions on a 'clean' performance, instead highlighting the things that are usually eliminated or tightly controlled in order to produce a professional rock band performance. There were a number of interruptions by electronic noise of one sort or another: feedback, distortion, and the sounds of things rustling and rattling when they should have been silent or non-existent. It was a reversal of the norms. The use of unusual sounds and the very low amount of direct repetition ensures that most events are variations on previous events, or contain something completely new. This is done in a way that builds onto what has occurred previously. In this way the form and content of the music clearly support the idea of transition in roles and the breaking of stereotypes. The sound-world is of a rock band, but really the music is about women under pressure to be different, and the strains imposed by change, welcome or otherwise. Such is the state of women in transition.

Appendix C. *Fuzzy IDEAS* applied to *Durations II* (Feldman, 1960)

Durations II (Feldman, 1960) is the music used in this worked example, which demonstrates how *Fuzzy IDEAS* works to discover possible ideas in this music along with the technical aspects of the music, which have stimulated those ideas, using my own experience of listening to this music. The first section provides detail on the information collected prior to listening to the music about prior knowledge of the music and the impact of the title as a framework for listening. The second stage, which is not directly documented in the analysis, is the collection of the qualitative listening observations while listening to the music in real time, while the fourth stage provides details of any problems encountered in the collecting the qualitative listening observations, and details the qualitative listening observations collected for each Reflective and Partially Indeterminate Event. The intermediate stages of the conversion to fuzzy logic entities and the visual representations of the fuzzified data are worked through, until the final Stage 9 draws out the ideas implied by analysis of these visual representations, in conjunction with earlier conjectures which emerged in previous Stages.

Stage 1. Documenting Pre-Listening Pre-Conceptions

The purpose is to identify what the listener brings to this particular listening experience. This section documents various aspects of mental preparation for the listening experience which will both affect and inform the actual experience of the music. This includes considering the possibilities suggested by the title for ideas in the music, along with any preconceptions brought to the listening experience through prior knowledge of the composer or the style of music.

Morton Feldman's name is familiar, coming to my attention through my interest in experimental music. I am aware that Feldman's work is considered an important contribution to modernist music of the late 20th century, without being able to recall any specific citation of his work. Despite passing references to Feldman's music, I have no knowledge of his techniques or why he is actually considered to be significant. Specifically, I am not aware of hearing this piece, nor any other of

Feldman's music prior to this listening. My general knowledge that his music is considered an important contribution to 20th century music leads me to suspect that the music will not be conventional tonal music.

The music is titled '*II*'. This implies that there was a previous piece of music, *Durations I* and there is a possibility of a *Durations III* or more, to follow, namely, this music is only one of a series of related pieces. To what 'duration' is specifically referring is unclear. The title could be referencing something experienced in real life, such as waiting to be released from prison. Duration, in this sense, is weighty: it has the mental/emotional association of being made to wait out time for a specific event to occur; it is not stimulated participation, nor necessarily excited anticipation. This leads onto further thoughts about possible form and content of the work which will generate this sense of continuing sameness which is the process of waiting, waiting, waiting....

Alternatively, the title could be referencing some aspect of music such as the length of sound events or phrases, perhaps implying a monotonous drone of varying lengths, perhaps implying contrasts. This could take any number of forms or content: short or long phrases and sections, contrasting fast and slow tempos, which impact on the duration of individual sound events. The title provides no clue about the sound sources to be used in this music. Presumably, this means that whatever the interpretation of 'duration', it is open to any or all sound types to produce the experience.

Stage 2. Collecting the Qualitative Listening Observations

I used pencil and paper to document qualitative listening observations about the music or my self-aware subjective responses while the music is playing, along with time points at which those qualitative listening observations were made.

My experience of listening to *Durations II* produced 14 listening observations at 14 time points over 7'10".

Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience

The documentation of the listening experience concludes with an account of the immediate impact of the complete piece of music as a sense-making experience.

The idea that occurred immediately after listening was that the purpose of the music was to engage the listener with the nuances of the sounds, to compare the sonic possibilities, the similarities and differences in sound types possible in the two different instruments, particularly as the Piano sounds were frequently left to fade out naturally.

The range of variation actually present in the music was quite limited. The Piano and Cello were sometimes in very close, or identical, Registers, sometimes in quite disparate Registers. The short notes were about 1" long, the long notes were longer than 10", and the very long notes I could not determine duration; there were only unisons or semitones, or leaps in similarly timed or adjacent events in the instruments, the only differences in character between pizzicato and bowed notes was the duration. The bowed notes did not have a sharp attack, nor any vibrato. Neither Sound Production Method was more accented or emphasised in any other way. This music was a succession of sounds in which very few things actually stood out. It was an encounter with music in which nothing conventional really happened, but rather simply having the experience of listening to finely nuanced sounds.

The music is a-rhythmic and a-metric and very slow, which caused me to continually lose sense of time. In essence, each sound event occurred in its own time-space, as there were no rhythmic accents to produce a sense of meter, while there was no regular pulse to provide any sense of tempo. In reality, keeping track of time, as required for *Fuzzy IDEAS*, was a significant distraction from the sounds as they unfolded. There was little overt harmonic dissonance in the music. There were no obvious harmonic suspensions or resolutions. The harmony was not challenging, it was pleasing to the ear, even in those rare occasions when the notes of the chords in the Piano created 'beats'. These 'beats' arise from the simultaneous sounding of two very slightly out of tune, yet in all other respects identical, notes on the same instrument. A piano has several strings for each note in the middle and higher

registers. Each of these strings is deliberately mistuned to provide resonance to these physically softer notes in conventional music played at regular tempos with denser textures. The design of Feldman's music provides the opportunity to hear the nuances of the sound of individual notes on the piano in a way that is not common in conventional music.

Another noticeable aspect of this music is the different orderings and their timing in relation to each other of the Piano and Cello entries as the music unfolds. The music began with alternating entries and then the order changed around. Additionally, the Piano part changes between being a contrapuntal second voice and a more regular chordal accompaniment. At various times the timing of the Piano in relation to the Cello was concurrent with, or sometimes followed the beginning of, sounds in the Cello. At times, the Cello emerged at the same pitch out of the Piano sound. By the end of the music the idea of a Homophonic (melody and accompaniment) relationship had become established in my mind, because of these changing temporal and registral relationships between the instruments through the course of the music. It seemed that the Cello was playing melody because of the occasional two quick notes in succession, while the Piano was mostly playing long notes which became the accompaniment.

The music did not seem finished because of the character of the final sound event, at 7'10", which consisted of two Cello notes which were short and in quick succession. This left me with the impression that there was more music to come, still yet to be heard. Indeed, this suggested that what had occurred was simply a very long drawn out phrase of a much larger piece of music.

Stage 4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations

Any problems arising while collecting the qualitative listening observations are documented here. This stage also provides the detailed qualitative listening observations which capture thoughts, reactions, memories, or images, that rise to conscious awareness in response to the sound of the music. These cognitive events may arise instead of, or as well as, any observations about technical aspects of the sound of the music.

I used a record player for the listening test. This meant using an analogue clock to determine the time points of the qualitative listening observations. The consequences being that the documented time points are likely to be less accurate in seconds and with different amounts of latency between noticing some aspect of the sound of the music and being able to identify the time points of the qualitative listening observations. Working out the timing of the sounds was quite a distraction from focussing on the qualities of the sounds, particularly when a notable event occurred.

Because the timing of the events was so hard to pin down on first listening, I listened to this piece of music again. In this second listening, despite the delineation of time points being the clear purpose and focus of this second listening, I had the same difficulty with keeping track of time. This seems to be a function of this music, which is essentially an a-rhythmic and un-metered unfolding at a very slow pace, of a few sound events of long duration, over a relatively large expanse of time.

The music was a simple succession of sounds in which very few things stood out. Even though every successive event was different from the preceding event, it was a slow motion experience when mostly nothing individually significant happened except the experience of the whole work rather than its individual events. The main qualities of the music was not the nature of the sound itself, but was in the different orderings and relative timings of the entries of each instrument. Another quality of the music that caught my attention was how sometimes the Cello sound emerged from the Piano chords, being at identical pitch. Other highlighted events were those occasions when the Cello played two quick notes in succession.

Particular events became notable when the instruments changed in their relationship to each other, whether registrally or in the time domain. However, as every event changed some aspect of the sound, there was nothing set up in the music as a base line for a typical sound. Thus, there was nothing against which to describe how the changes affected the sound in a relative sense. The simplicity of each sound event rendered irrelevant most proto-typical concepts derived from music theory. The sounds of this music cannot easily, or accurately, be described by conventional terms from music discourse such as 'harmonic progression', 'rhythm', or 'meter'. Some conventional attributes, such as Amplitude, or Tempo, were never

consciously present in the music, while other grouping attributes such as ‘melodic movement’, simply seemed irrelevant to the sounds at hand because the slowness of the music resulted in complete focus on one sound event at a time. The actual sounds were not difficult to experience, but it was difficult to capture in words the range of subtleties inherent in the current sound event. Ultimately, that part of the music most documented is the Cello, because this caught my interest through nuances in sound events due the greater variety of Sound Production Methods available to this instrument. The Cello also has the greatest differences between event durations. Those in the Piano are more standardised.

Table C.1 below, provides the listener’s qualitative descriptions of cognitive events and any technical observations associated with those thoughts or insights. Table C.1 does not list all the qualitative listening observations for the whole of this listener’s experience. Rather Table C.1 only details those qualitative listening observations that contain cognitive processing associated with self-awareness of perception, memories and reactions to the sound of the music; moments of focused attention on the music; along with any moments at which the listener has become consciously aware that particular aspects of the sound of this music have stood out. In preparation for the ‘fuzzification’ of this information during Stage 5, in accordance with the rubric for the method, all documented time points are quantised downwards to the nearest five seconds.

Table C.1. *Durations II: List of Cognitive Events*

Event Number	Time Point	Event Description
E0	0’00”	Both Piano and Cello play at the same time.
E5	1’50”	Bowed Cello notes in the high register, occur right across this time point.
E6	2’20”	Pizzicato events start here.
E7	3’10”	Bowed events start here.
E12	5’30”	A bowed note in the high register emerges into consciousness around this time, which is difficult to pinpoint exactly.

Stage 5. Converting the Qualitative Listening Observations into Fuzzified Data

There are two unusual occurrences in the qualitative listening observations for this music. Amplitude is never documented in this experience of this music, while the only Event Durations which were documented are the relatively faster events.

The fuzzy entities I selected for classifying technical attributes and features are shown in Table C.2 below. This table shows the technical details in the qualitative listening observations organised into attributes and then feature sets. This classification is designed to cover the sounds of this music in the most comprehensive yet efficient way. These attributes and feature sets will be used to represent this listening experience in visual form.

Table C.2. *Durations II*: Technical Attributes and Feature Sets

Attribute	Feature Sets		
Time	The smallest time interval between recorded events is 10"		
Register	Very High	High	Low
Event Duration	Quick		
Texture	Duet: two distinct groups with mostly similar technical qualities Monophony: groups of single notes or chords of the same sound type Repeating Sounds Single Sounds		
Sound Production Method	Bowed	Pizzicato	
Sound Source	Piano	Cello	

Stage 6. Constructing Visual Representations of the Fuzzified Data

The purpose of this stage is to report the fuzzified data in a visual format which directly represents various aspects of this personal experience of the music. The visual representations are constructed from the fuzzified data for each sound event at both attribute and feature set level. The quantisation interval selected for mapping the fuzzified data into the visual representations is based on the smallest time interval between the quantised time points, which here is ten seconds.

The fuzzified data in time series at the attribute level gives the single most complete overview of the listening experience. This visual representation is provided in Figure C.1 below.

By contrast, the fuzzified data at the feature set level across time gives the most detailed visual representation of the listening experience. This level of detail requires multiple visual representations which are presented in Figures C.2-C.8 below.

a. Attribute Combinations across the Time Domain

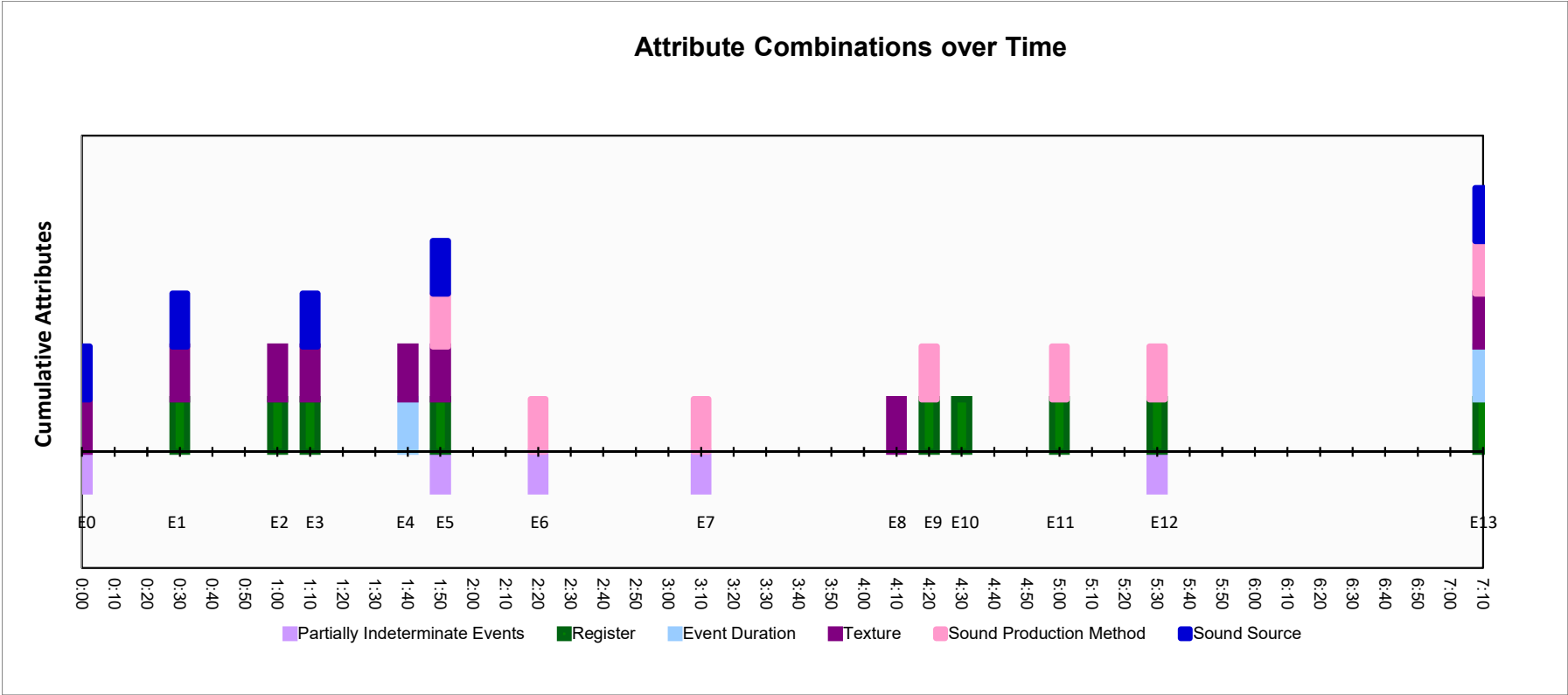


Figure C.1. *Durations II*: Attributes across the Time Domain

b. Fuzzy Feature Sets across the Time Domain

There are no documented Reflective Events.

Figure C.2. *Durations II*: Feature Sets of Reflective Events over Time

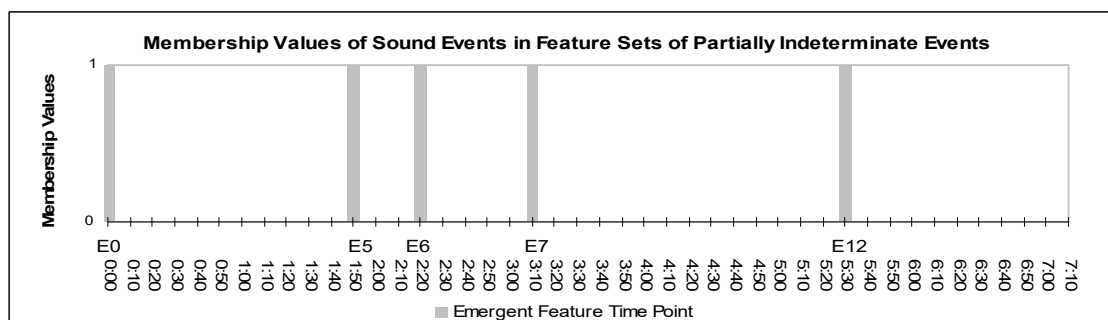


Figure C.3. *Durations II*: Feature Sets of Partially Indeterminate Events over Time

There are no documented Amplitude Events.

Figure C.4. *Durations II*: Feature Sets of Amplitude over Time

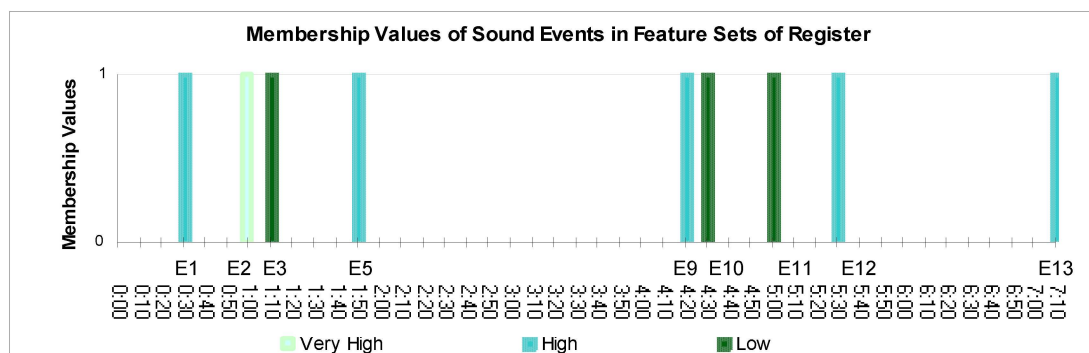


Figure C.5. *Durations II*: Feature Sets of Register over Time

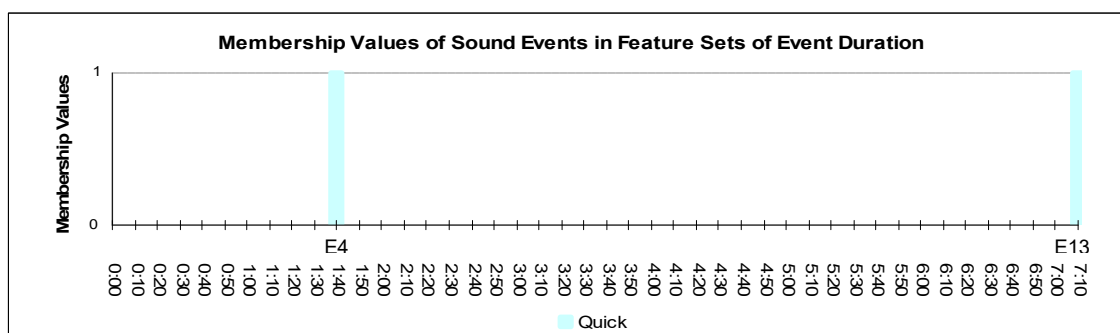


Figure C.6. *Durations II: Feature Sets of Event Duration over Time*

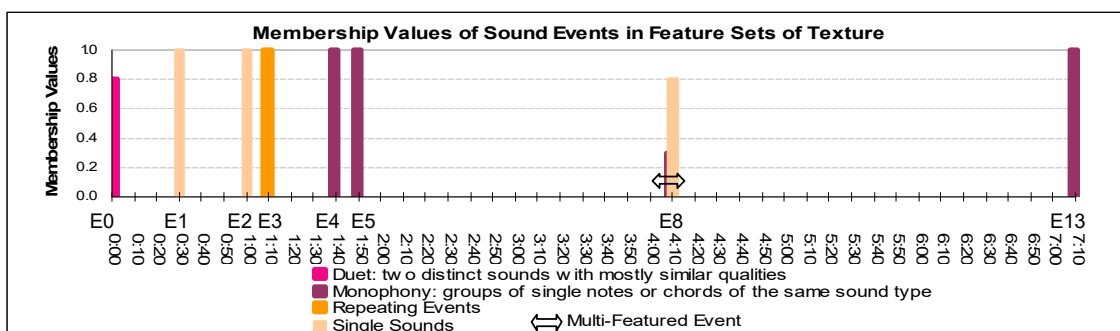


Figure C.7. *Durations II: Feature Sets of Texture over Time*

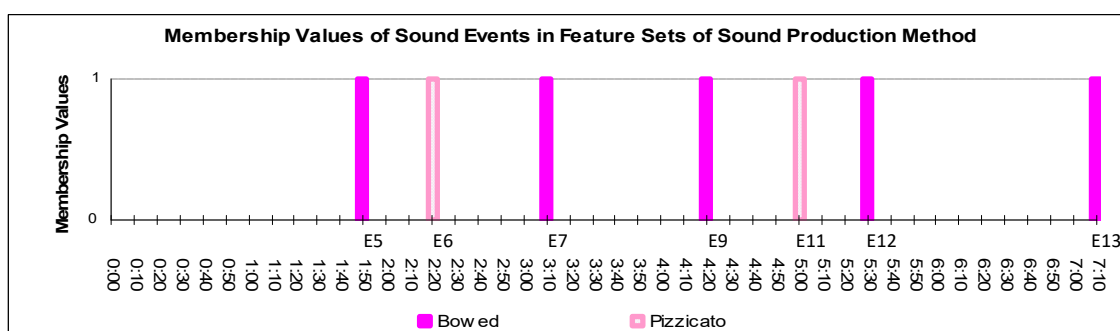


Figure C.8. *Durations II: Feature Sets of Sound Production Method over Time*

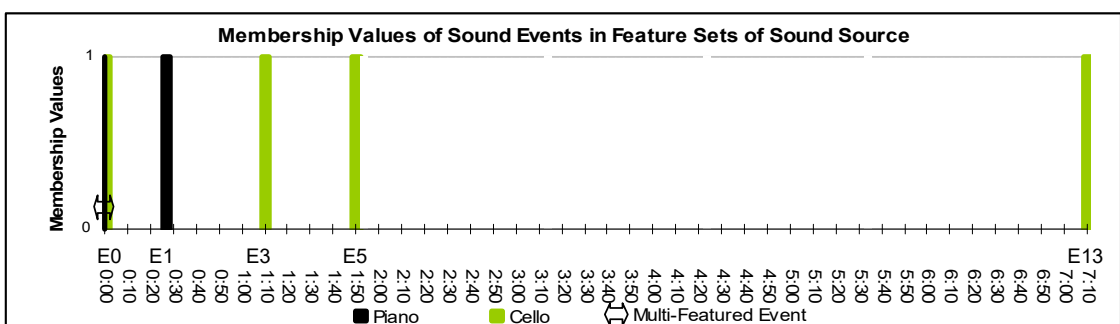


Figure C.9. *Durations II: Feature Sets of Sound Source over Time*

Stage 7. Analysing the Frequency of Fuzzy Entities in the Visual Representations

This stage summarises the information conveyed by the visual representations to draw out those attributes and features highlighted in this single experience of the music. These significant occurrences imply that these particular qualities have been emphasised by the composer. Relative frequency of attributes and feature sets also indicates the amount of variation between individual sound events.

a. Frequency of Attributes

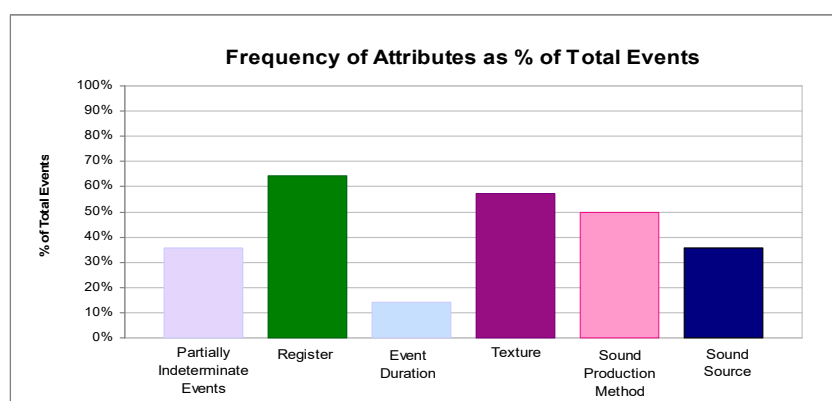


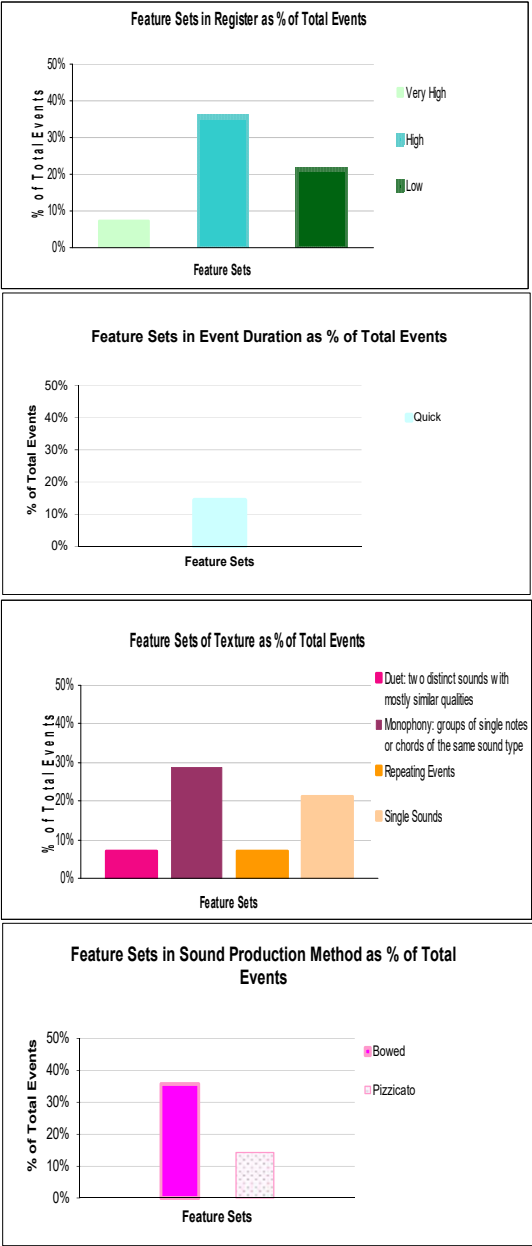
Figure C.10. Durations II: Frequency of Attributes

Register, Texture, and Sound Production Method are the most frequent attributes, while Sound Source and Partial Indeterminate Events are common attributes of the observed events. Register is included in 64% of all events in this music, 57% of Events include Texture and Sound Production Method, while Sound Source is included in 35% of events. Partially Indeterminate Events are also documented for 35% of total sound events. Event Duration has only been recorded for two sound events (14% of total events). There are no events which include Amplitude, nor are there any documented Silence Events. Quite significantly there are no Reflective Events as there were no allusions in this music to other music, and there was nothing that caused me to reflect on any aspect of the unfolding of the music.

b. Frequency of Sound Events in Technical Feature Sets

Each attribute is broken down into its constituent fuzzy feature sets. Figure C.11. *Durations II*: Frequency of Technical Feature Sets below provides a set of histograms, each of which shows the proportion of total sound events included in each individual feature set within an attribute.

There are no feature sets for Amplitude.



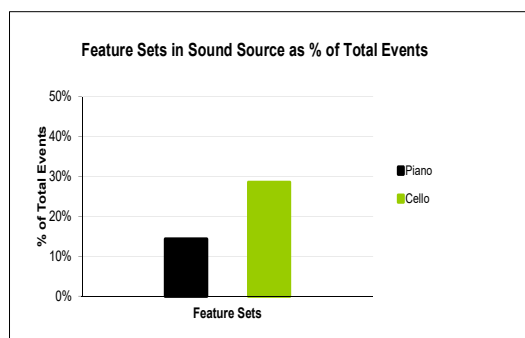


Figure C.11. *Durations II*: Frequency of Technical Feature Sets

Due to the small number of recorded events in this music, looking at percentages can be somewhat misleading, as one event represents 7% of total events. Thus, some of the feature sets can appear to be more universal across this music than they are in practice. Still, keeping this in mind, it is possible to identify those features that occur rarely. For example, Event Duration is documented for only two events in total, which both fall into the Quick feature set. These sound events were obviously quite distinct in this music as there are so few members of this feature set and being the only feature set in this attribute.

Other feature sets which contain 35% of total sound events are High in the attribute of Register and Bowed in Sound Production Method. The feature set of Cello in the attribute of Sound Source contains 28% of total sound events.

The attribute of Texture contains four feature sets. This music relies on simple Textures throughout, as even the Piano chords consist of only two notes. Consequently, even though the variations between events are very small they become significant. Hence the feature sets for Texture in this analysis represent quite fine grained distinctions between the sound events. Most Textures are Monophonic (28% of total events) or Single Sounds (21% of total events).

c. Frequency of Feature Sets of Partially Indeterminate Events

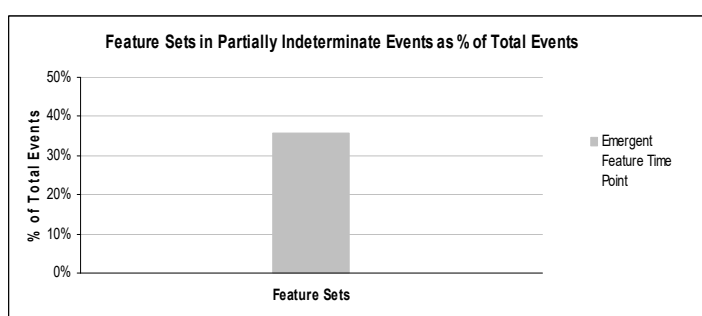


Figure C.12. Durations II: Frequency of Feature Sets in Partially Indeterminate Events

35% of total sound events are classified as Partially Indeterminate Events. These Partially Indeterminate Events occur in only one feature set in this music: Emergent Feature Time Point. This shows that more than one third of events do not have clearly perceptible boundaries in the time domain. This feature set is one of the most frequent among all the technical attributes.

d. Frequency of Feature Sets of Reflective Events

There are no documented Reflective Events for this experience of this music.

Figure C.13. Durations II: Frequency of Feature Sets in Reflective Events

No Reflective Events have been documented in the qualitative listening observations for this listener. The music did not contain any allusions to other music, no listener recall or self-reference to its own materials, nor have any events more noticeably focussed my attention. In the overall context of this music, there were no particularly unusual or provocative sounds. There was nothing in the sound of the music which caused me to ‘think’ about the sound of the music while listening. The reflective questions about the music were on a larger scale than the individual sound event.

e. Frequency of Attribute Combinations

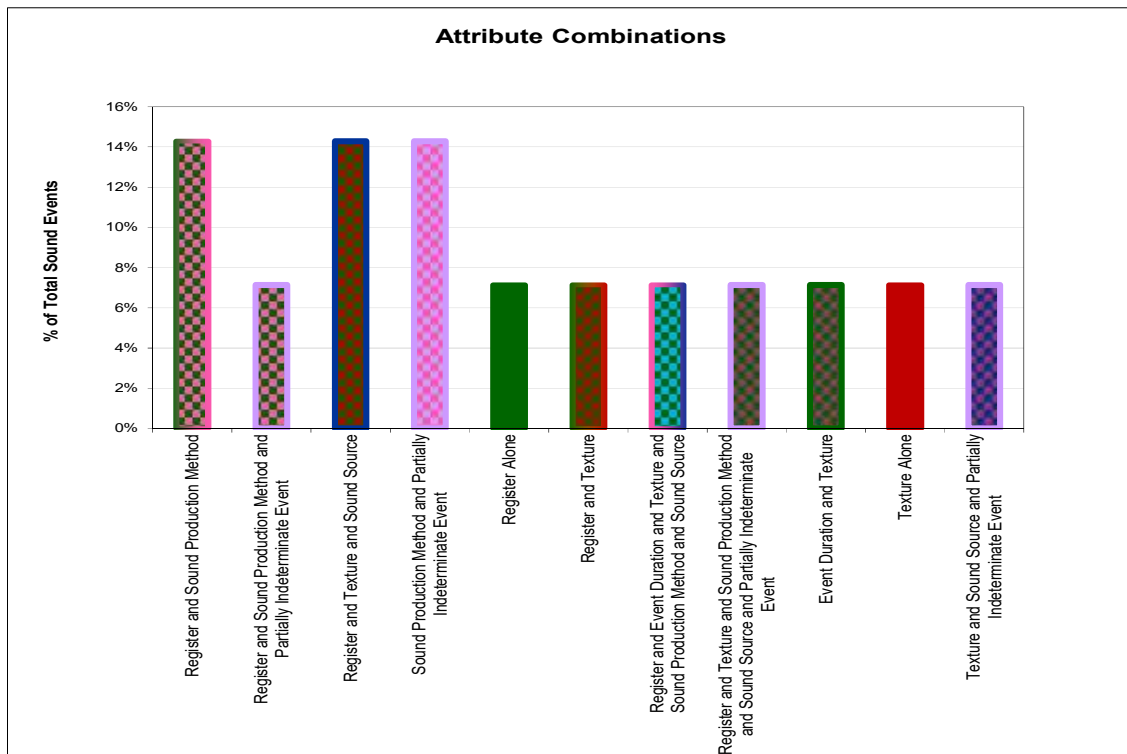


Figure C.14. Durations II: Frequency of Attribute Combinations

Figure C.14 shows the frequency distribution of Attribute Combinations. This shows the degree of similarity between all events at the attribute level. Partially Indeterminate Events are included in 40% of unique Attribute Combinations. Considering that there are only 14 events, the existence of several duplicated combinations is of interest. Three Attribute Combinations are each duplicated somewhere in the music, which means that eight of the 14 (57%) individual events have unique Attribute Combinations.

Four sound events (28% of total events) had only one technical attribute: Sound Production Method Alone accounts for 14%, while Register Alone accounts for 7% and Texture Alone accounts for 7%, representing one single sound event each. This implies that most events have more complexity than simply identification of the Texture or Register.

In *Durations II* the most complex events could have a maximum of five technical attributes, recalling that Amplitude is not present in this experience of this music. One sound event contains all five technical attributes, while another contains four.

f. Frequency of Transition Pairs

Transition pairs arise from a comprehensive comparison of all attributes between adjacent sound events across multiple attributes. Cognitive Events, including Partially Indeterminate Events are included in these Transition Pairs.

All Transition Pairs occur only once in the whole piece. There are no recurring Transition Pairs in this music. This shows that there is no clear self-referencing or repetition of any other portion of this music.

There is one Attribute-identical Transition Pair, E6-E7 at 2'20 to 3'10", which has the attributes of Sound Production Method as well as being Partially Indeterminate. This suggests that there is very little direct replication of combinations of notable sonic qualities. Seven Transition Pairs (53% of all pairs) include a Partially Indeterminate Event in at least one event of the two.

Table C.3. *Durations II*: Duplicated Transition Pairs at Attribute Level

There are no repeated Transition Pairs in this experience of this music.

Stage 8. Analysing the Time Structure of the Visual Representations

The second type of analysis on the fuzzified data explicitly focusses on visual analysis of the time-patterning of attributes, features, and Silence events. This is achieved by constructing a set of analytical charts from the time point visual representations. Each analytical chart addresses a single aspect of the time point representations of the fuzzified data.

a. Time Structure of Attributes of Silence Events

There are no Silence Events in this experience of this music.

Figure C.15. *Durations II*: Silences and their Qualities over Time

The most obvious thing to emerge from the visual representations of the fuzzified data for *Durations II* is that there are no documented Silence Events. Particularly, there is no Silence Event documented at the end of this music. The final event seemed abrupt and left me with the sense that more could have followed.

b. Sectional Segmentation by Silence Events

There is no segmentation by Silences in this experience of the music

Figure C.16. *Durations II*: Sectional Segmentation using Silences as Break Points

As observed in the previous section, there are no Silence Events, hence this experience of the music suggests that the music is a whole piece, without any sectional segmentation.

c. Event Complexity over Time

Attribute Combinations over Time shows the distribution of event complexity over time, while Partially Indeterminate Events represent a different form of complexity in that the sound events contain inherent complexity of each of the sound of the music as recorded in the qualitative listening observations.

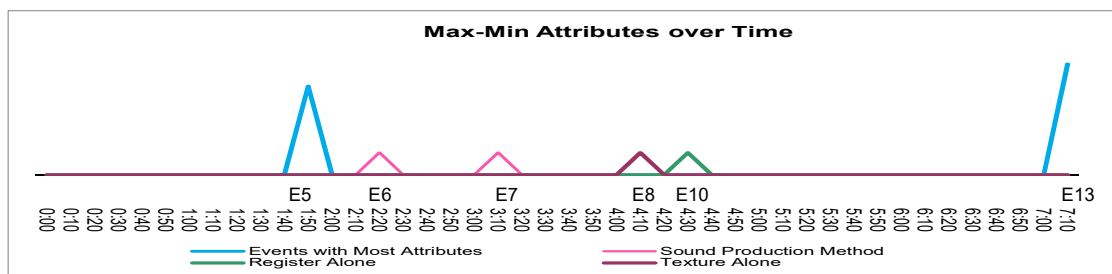


Figure C.17. *Durations II*: Max-Min Technical Attributes across Time

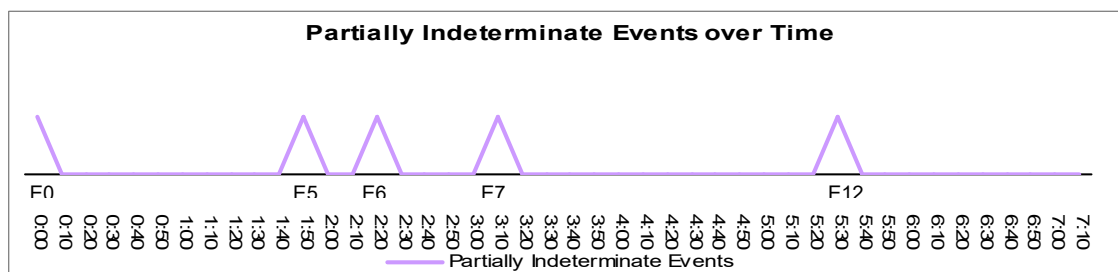


Figure C.18. *Durations II*: Partially Indeterminate Events across Time

Figure C.17 above summarises Figure C.1: *Durations II: Attributes over Time*. The most complex event in *Durations II* has five simultaneous technical attributes, while the least complex events have only one attribute, namely Register Alone, Texture Alone or Sound Production Method Alone. The Single-Attribute events begin one-third of the way through the time domain of the music, E6 at 2'20" until E10 at 4'30". The Triple-Attribute events occur only in the beginning of the music until E3 at 1'10". The most complex events are E5 at 1'50" and E13 at 7'10". However, the initial complex event E5 does not occur until 1'50" into the music. This initial time interval is fuzzily equal in visual terms, to the intervals between the other events in this analytical chart. This suggests that the music is divided into four equal parts by those events with either the largest or smallest number of attributes.

Figure C.18 generalises the previous Figure C.3. *Durations II: Feature Sets of Partially Indeterminate Events over Time*. There is more uncertainty in the first half of the music, where four sound events are Partially Indeterminate Events. By contrast there is only one Partially Indeterminate Event in the second half of the music, E12 at 5'30".

For *Durations II* these two charts show that the two different dimensions of event complexity, (both documented complexity and documented uncertainty), suggest overlapping temporal designs, because a number of the Partially Indeterminate Events occur simultaneously with the least and most complex sound events.

d. Most Common Attribute Combinations over Time

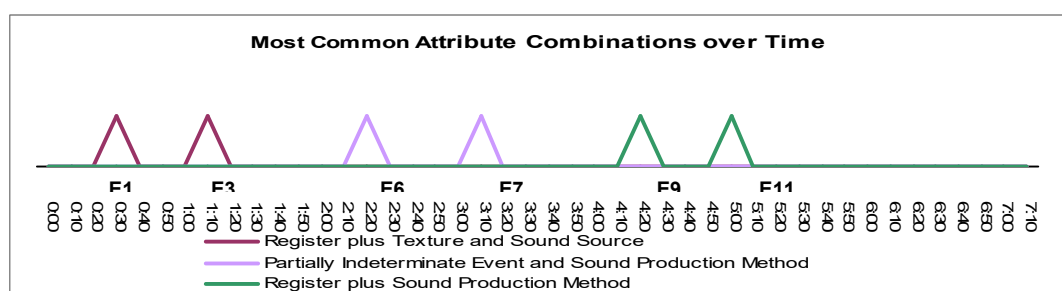


Figure C.19. *Durations II: Most Common Attribute Combinations across Time*

The music as a whole is examined for the time points of the Most Common Attribute Combinations, looking for obvious replications of sound events with identical attribute combinations across the time domain. This analytical chart includes all

attributes, cognitive as well as the technical attributes. This is different than the previous analysis of the contour of technical complexity, because it places cognitive events on an equal footing with any technical attribute(s). For some listeners, cognitive events may be their primary way of responding while listening to the music. In these instances, this analytical chart allows that information to rise to the surface. Overall, this analytical chart provides information on whether and when specific sound events with identical components are repeated. This information can imply repetition or variation as the music unfolds which gives another insight into possible formal structures such as Rondo, where the opening theme is repeated several times after interjected alternate sections.

Figure C.19. *Durations II: Most Common Attribute Combinations across Time*, shows that the first of the frequent Attribute Combinations is E9, at 3'20", which is a Texture Alone Event. The first Register and Texture sound event occurs at E11 at 3'45", and also E13 at 4'30" alternating with another Texture Alone Event until E15 at 5'00". This group of alternating combinations has a duration of 1'40", half the duration of the time interval before E9 at 3'20". There are further suggestions that 1'40" is significant because the five Texture Alone events from E20 at 6'40" to E28 at 8'25" occur in the same time interval of 1'40". Then, however, Texture Alone does not recur in the remainder of the music. Instead the Register and Texture events immediately dominate the music, from E29 at 8'40" to E45 at 13'10". These six events occur in a mirror pattern in this time interval of 4'30".

There are individual sound events with the attributes of Register Alone and Tempo Alone events, E33 at 9'40" and E34 at 9'55" respectively, which occur in the second half of the music.

e. Repeated Transition Pairs at Attribute Level

There are no duplicated Transition Pairs in this experience of this music.

Figure C.20. *Durations II: Repeated Transition Pairs across Time*

There are no repeated Transition Pairs documented for this music. Logically, this means that all Transition Pairs are equally common. The visualisation for this occurrence is empty, and has been omitted for brevity. The implication of all unique Transition Pairs is that there is no direct self-referencing to, or repetition of, other parts of the music. Alternatively stated this means that the music is one continuous piece, varying from beginning to end.

f. Time Structure of Feature Sets

At the instant of E0, each single note played by both instruments was quite balanced, similar to a Duet. However, as this was the first event of the music, the actual Textural relationship between the instruments was still to emerge. E3 at 1'10" contains Register, Texture and Sound Source. Nearly all those Features of these four attributes which are used later in this music occur once in these opening four sound events. E4 at 1'40" appears to be a significant point in the music because it contains the first Feature of Event Duration, and a hitherto unused Feature of Texture.

The Monophonic Texture occurring at E4 at 1'40", is duplicated at E5 at 1'50". E5 begins a mirror image around E8 at 4'10" an event with the most complex Texture in the whole of this music, completed by E13 at 7'10" which also includes Monophonic Texture. Much of the preceding information suggest that events up to E3 at 1'10" are introductory material, or a prelude to the main section of this music, which begins on E5 at 1'50" and continues until the final event, E13 at 7'10". From this perspective, E4 at 1'40" and E13 at 7'10", which have identical features in Event Duration as well as Texture, are anacrusis events which lead into main sections of the music, yet *Duration II* actually only contains one of these sections. E13 at 7'10" is an elision, both a culminating event for the previous section, and an introduction to the next section which will follow on from E13 at 7'10", yet to be realised.

Additionally, the temporal distribution of the Features of Register do not fit this single section pattern with obvious ease. There is a group of events in Register between E9 at 4'20" and E12 at 5'30" with similar timing and variation in feature sets, to one group of events in Sound Production Methods. The patterning of features of Register in this time interval repeat quite closely the pattern of features in Register in the opening section. However, Register is completely absent for the time intervals between these two groups.

The temporal distribution of feature sets in Sound Production Methods is clearly divided into four blocks, within a repetitious structure outlined by the Bowed sound events. Another repetition of the previous groups in Sound Production Methods could possibly be starting at E13, at 7'10", the final sound event of the music. Even though the overall temporal distribution of Features in these two attributes is somewhat dissimilar, it could be fuzzily considered to outline four sections.

There is other evidence which also suggests this second possibility, that the music is in four equal sections each of which demonstrates the outcome of overlaying different but related Attribute Combinations on a sequence of sound events. In conventional music theory this would be called a set of variations. Evidence for this possible structure is based on the temporal distribution of feature sets in Register and Sound Production Method mentioned previously. These four sections are also outlined by the distribution of feature sets in Partially Indeterminate Events. The time interval between E0 at 0'00" to E5 at 1'50", if directly replicated twice from E5 coincides perfectly with the timing of E12 at 5'30", and is fuzzily equal to the time interval between E12 at 5'30" and the end of the music. As already stated, the feature sets of Register, Texture and Sound Production Method all show a similar distribution over time.

Stage 9. An Abductive Interpretation: The Idea that Makes Sense of this Experience

This stage draws out the overall key idea suggested by this experience of the music, and what this experience suggests about the compositional design. These abductive conclusions follow through on earlier hypotheses formulated immediately before listening presented in Stage 1, and immediately after listening presented in Stage 3, as well as the implications of the analyses presented in Stages 7 and 8. In Stage 9, this synthesis links the technical features observed during listening and the previous hypotheses, to draw conclusions about the idea that makes sense of this experience.

a. Implications of Frequency of Technical Attributes, Attribute Combinations, and Feature Sets

The dominant attributes and features suggest that these sonic qualities have been emphasised by the composer, while the frequency of occurrence of sound events and the range of feature sets indicate the amount of variation between sound events.

This music does not have any peculiar attributes, clearly relying on conventional acoustic instruments and playing techniques to produce conventional sound events. What is noticeable, is that several attributes occur often. Register, Texture and Sound Production Method are documented for 56% of total sound events. Sound Source and Partially Indeterminate Events are documented for five (35% of total) sound events. Event Duration is only documented for two events. No Amplitude or Silence Events break into the music, hence the sequence of sound events was very stable over time, with little variation in duration. Register contains the highest number of events (nine), yet has only three feature sets. Apparently the music is a collection of quite repetitive and simple sound types.

Textures are actually fine grained distinctions in the relationship between the instruments in different sound events, rather than strong distinctions between the number and type of voices over groups of sound events. Half (50%) of all documented sound events are either Monophonic or Single Sounds. Only 14%, one event each, are documented as Duet or Homophonic, hence the activity of one instrument was more notable than the combination. The frequency and nature of feature sets in Sound Production Method and Sound Source both show that Cello was of most interest. The other attributes only contain one or two feature sets. There is not much variation across attributes. Thus the nuances of sound are important in determining what was notable for documenting sound events.

Eight Attribute Combinations only occur once during the music, while three Attribute Combinations each occur twice. The repeated Attribute Combinations are Register and Texture and Sound Source; Partially Indeterminate Events and Sound Production Method; Register and Sound Production Method. Together these repeated combinations include 54% of the total number of sound events which contain either Register and/or Sound Production Method. This suggests that Register and Sound Production Method are frequent points of interest in this music.

Only one Transition Pair is Attribute-Identical, E6 to E7, at 2'20" to 3'10". Both sound events contain Sound Production Method and are Partially Indeterminate Events. These two events are the central points in the documented events, even though they only occur about one third of the way through the music. All Transition Pairs are unique, which shows that there is no recall or self-reference to other parts of this music. This suggests that the music does not contain sectional repetition, rather that the music is continuously changing, with a lot of variation.

b. Implications of the Uncertainty Experienced by this Listener

Uncertainty is suggested by various aspects of the results. It is reflected by the number of Multi-featured events; the number and types of Partially Indeterminate Events; and the qualities of the Silence Events.

Five of the 14 sound events (35% of total events) include Partially Indeterminate Events which are all Emergent Feature Time Points. Partially Indeterminate Events are included in one or both of the sound events in 53% of Transition Pairs. This demonstrates the uncertainty around the boundaries of individual sound events, although this uncertainty gradually diminished as the piece of music unfolded over time, as the sounds became normalized and a tentative idea grew more possible as the sounds and reflections accumulated. This idea partially grew from the uncertainty regarding the boundaries of individual sound events. The idea taking shape is that the purpose of the music is to explore the nuances of sound in order to compare the sounds produced by the two instruments.

Multi-featured events denote the ambiguous nature of individual sound events that contain elements pertinent to several feature sets in the same attribute. Partially Indeterminate Events by definition denote events with uncertain boundaries, whether in the time domain or the technical description.

There is only two Multi-featured events in this music, E0 at 0'00", the very first sound event, which contains both Cello and Piano in the attribute of Sound Source each with a membership value of 1, which shows that this event completely and simultaneously satisfies the criteria for both fuzzy feature sets. The second Multi-featured event, E8 at 4'10", contains some uncertainty regarding the Texture of this

sound event, so this sound event contains qualities of two feature sets, although with varying membership values.

Over 1 in 3 sound events across all attributes are classified as Partially Indeterminate Events, all of which are Emergent Feature Time Points, which occur when the listener becomes aware of something only because continuation had brought it to consciousness.

c. Implications of Reflective Events

No Reflective Events have been documented for this experience of this music. The music did not contain any allusions to other music, no listener recall or self-reference to its own materials, nor did any events noticeably focus my attention. *Durations II* was a succession of sounds in which very few things actually stood out. It was an encounter with music in which nothing conventional really happened, but rather simply having the experience of listening to finely nuanced sounds.

d. Implications of the Time Domain: Silences as Break Points

The most obvious thing to emerge from the visual representations of the fuzzified data for *Durations II* is that there are no documented Silence Events, hence the music could be considered to be 'through-composed'. While this technically true for this music, this formal term suggests that this music is completely self-contained. However, there is no Silence Event documented at the end of this music. This suggests that the music actually is not finished. The final event seemed abrupt and left me with the sense that more could have followed.

e. Implications of Attributes over the Time Domain

This representation of the music contains 14 sound events over 7'10", hence the average time between documented sound events is 30". The visual representations of the music clearly show that some of the documented events occur within 10" of each other, while others are much further apart, indeed at a time interval of 1'40" by the end of the music. One of the outstanding aspects of the fuzzified data is that there are no documented Silence Events. As a result, there are no clearly marked endings of sections, not even at the conclusion of the music.

The first four sound events up to and including E3 at 1'10" are a distinct group. The only Partially Indeterminate Event in this group occurs at E0, demonstrating the uncertainty of how the instruments relate to each other at the opening of this music. E5 contains the attributes of Partially Indeterminate Events, Register, Texture, Sound Production Method (this is the first event which includes this attribute), and Sound Source. In fact, every attribute except Event Duration. The trajectory of complexity over the time domain begins with group of complex events from the start of the music to E5 at 1'50" then becomes simpler by E10 at 4'30". The music then grows more complex again, over a similar time span of 2'20" to the end of the music.

This possible segmentation is reinforced by the following patterns. 1. following the block of sound events which feature Sound Source up to E5 at 1'50", there is complete omission of Sound Source after E5 at 1'50", until the final sound event E13 at 7'10". 2. Event Duration immediately precedes the section at E4 at 1'40" and is then also absent until the final event being part of E13 at 7'10". 3. Texture also outlines this larger section, in different but similar ways. 4. Sound Production Method first occurs only at E5 at 1'50", being then included for every successive event for the remainder of the music, except E8 at 4'10" and E10 at 4'30".

The time intervals between groups of Register events are different, so that the four blocks of time do not have the same boundaries as those of Sound Production Method. However, the analytical chart, Figure C.19. Most Common Attribute Combinations across Time, suggests that the music is in four sections, each of which features a different attribute. Looking back to Figure C.1. Attribute Combinations over Time clearly shows that different attributes and combinations of attributes are featured during four similar time spans during the music. Initially, Texture, Register and Sound Source are important, which then changes dramatically to Sound Production Method, which then continues in the next part with the addition of Register, then an interval in which no sound events are documented, culminating with the most complex event of the music as the final event.

However, Partially Indeterminate Events shown in Figure C.18. show a different pattern, which does not directly contradict the four section pattern, but rather is a source of variation between the four sections. The distribution of Partially Indeterminate Events is concentrated in the time interval E5 at 1'50" to E7 at 3'10".

f. Implications of the Time Domain at the Feature Set Level

Visual analysis of fuzzy feature sets in individual attributes across the time domain reveals a number of identifiable patterns over some portion of the music. Several attributes showed various component feature sets with varying trajectories which interacted to produce different results. Together these temporal distributions of feature sets suggest that this opening section is a display of possibilities. From this point on there are two possible interpretations.

The first possibility is that, following this short introduction, all the sound events from E5 at 1'50" up to E13 at 7'10" are a separate and important segment of the music. In *Durations II*, the temporal distribution of features within all the attributes, including those with relatively few events such as Event Duration and Sound Source, suggests that the music is either in two sections of unequal length, or in four sections of fuzzily equal length.

This second possibility, that the music is a set of variations, seems more plausible based on the visual representation of the feature sets over time. The two events in Event Duration can still be anacrusis events, not only linking section two to a possible section five, suggesting that there is more to come, as only some of the possible variations in the qualities of sound and Textures have been incorporated into this existing music.

The Abductive Idea that Makes Sense of this Music

All the previous contemplations and analytical implications are combined to suggest an idea as the foundation on which this music was composed. I am not arguing that this idea is the correct interpretation, or that every listener will or should make sense of this music in this way, or that the composer intended to communicate this specific idea, or rather this idea is one possible way to make sense of this music.

Potential Idea 1: Implications of the Title

The title holds no concrete indications about the sound world or the form of the music or to what 'durations' actually refers: the length of sections, and/or the length of the sound events.

Potential Idea 2: Immediate Impressions

My first conscious thought about *Durations II*, was about its structure; that this music sounded like a slowed down portion of a much larger piece of music. In fact, there was no extra silence, *diminuendo*, or slowing of tempo to indicate phrase endings, not even at the end of the music. Rather the final event of the music, two successive Quick notes in High Register rising in pitch, was one of the most unusual events in the whole work. This final sound event was an atypical ending to a complete work based on very long event durations. This added to the sense that this extant music was only part of a much larger work, perhaps that the whole of this music was either one or three phrases unfolding at an extremely slow tempo.

However, the idea that occurred immediately after listening was that the purpose of the music was to engage the listener with the nuances of the sounds, to compare the sonic possibilities, the similarities and differences in sound types possible in the two different instruments, particularly as the Piano sounds were frequently left to fade out naturally.

Potential Idea 3: Logical Conclusions from Visual Analysis

The music seems to be focussed on the nuances of sound itself. Also, the compositional ideas revealed by this analysis are different from most possibilities suggested by the title. The exception is that the number in the title of the work suggests that this music is part of a larger sequence all exploring 'durations'. The unfinished nature of this piece of music ties in with this idea that there is more to come. For a work of seven minutes in length, it contains very few events overall. So each individual event became significant in its own right. The fact that the time intervals between sound events gradually increase shows how immersive the sounds of the music became, or rather, how irrelevant time became to the experience of listening. This is reinforced by the lack of Reflective Events, and the absence of any documented Tempo or Amplitude which both can impact on the sense of time passing. There was no boredom nor anticipation, no 'thinking', simply 'observation' of the sounds as they unfolded.

Yet an important aspect of listening to this music is that I was always attentive and focussed on the sound of the music, possibly because the small variations in sound

events were interesting to hear but consistently difficult to document because of being so nuanced, with few external reference points from which to start describing them. There were no allusions in this music to other music. During listening, the sound of the music was just simply being itself.

An Abductive Interpretation: The Idea that Makes Sense of this Music

The preceding analysis of the experience of this music has produced three different yet not incompatible ideas. First, the music explores the nuances of sound produced by the instruments perhaps to compare and contrast their inherent sonic possibilities. The second idea is that the music is designed to challenge the usual sensation of time in music: reflected by the title 'Durations', by the real difficulty in keeping track of time while listening, the absence of rhythm and pulse in the music, the irrelevance of tempo, and the immediate response after listening. The third alternative is that this music is designed as a formal set of variations, leaving open the possibility that there are more yet to come, than those which are contained in this music. One thing is clear. All these possibilities are technical; they reside in the succession of sounds in the music itself, rather than being referenced by the title or individual sound events prompting extra-musical associations.

First, the compositional idea that the music is about the nuances of sound is different from, although related to, the possibilities inherently suggested by the title. Yet the relevance of the title, in this interpretation, is effectively an act of omission. Because the title holds no concrete indications about the types of sounds or the form of the music, the title generated very few expectations of how the music would really sound, except perhaps drones of varying lengths.

'Duration' in the title clearly refers to this individuation of sound events because each sound event is an object in its own right, rather than simply being a small part of a much larger construct 'the music' where each individual note tends to insignificance. This concept is difficult to denote or measure in conventional music terms which are concerned with relative individual length, such as quaver or minim, which are then impacted by global variables such as tempo or metric subdivisions.

My actual experience of timelessness in the listening could be construed as following one possibility offered by the title. Namely, the mental/emotional concept that

duration is often a state of waiting where time can seem endless. However, I wasn't actually experiencing that sense of anxious impatient anticipation that is part of waiting; rather it was just as if Time had disappeared. Also, the compositional ideas revealed by this analysis are different from most possibilities suggested by the title. The exception is that the number in the title of the work suggests that this music is part of a larger sequence all exploring 'durations'. The unfinished nature of this music ties in with this idea that there is more to come.

This piece could be about the possible similarities of the sounds produced by the two instruments. The effect of the combination of very few events in seven minutes, in which the Cello dominates the listening experience, although clearly still related to the Piano, is an important aspect of this work. The small nuances in texture, and the small range of feature sets in all the attributes, along with the Emergent nature of over one third of the sound events, do little to provide any consciously memorable temporal design. The similarity of the Piano and Cello sounds is striking considering they are such differently constructed instruments. For instance, Piano sounds are typically produced by a hammer striking a string quite loudly, which then is allowed to decay to silence. This is similar to *pizzicato* on a Cello string. Yet the Cello is played without *vibrato* and the attacks of both instruments are consistently similar. This reinforces the idea that this music is about sound quality, as does the opportunity to hear the 'beats' in the sustained Piano sounds.

A second possibility is that this music is designed to directly address the qualitative experience of time. One of the distinctive aspects of music, as an artform, is its nature as it necessarily unfolds over time. Plausibly, *Durations II* takes on the challenge of directly manipulating this dimension of music. This possibility makes sense of *Durations II* because this music is a-rhythmic and un-metered. The timing of entries of Piano and Cello frequently change in relation to each other, so that there was no regularity of pulse established by the entries of either instrument or both. This design encourages losing a sense of time. As well, the slow unfolding of the music meant it was difficult to recall anything specific about any event after a short time had elapsed, as the next sound event was so enveloping. This formlessness is reinforced by the mirroring of feature sets within attributes around sets of time points. The mirror time points vary for each feature set within a single attribute, so that there are no repeated sounds from one event to the next, let alone

repetitions of groups of sounds. Even E6 at 2'20" and E7 at 3'10", have different features even though they are Attribute-identical.

The third possibility for making sense of this music is that it is working with uncertainty of formal design: how the music is structured over time. Perhaps the music is titled 'Durations' using this word as an alternative to 'phrase' or 'section' as a piece of a larger work. As discussed previously, there are two structural possibilities inherent in the visual representations of the feature sets and Attribute Combinations over the time domain. Firstly, this music has characteristics of being a slowed down single phrase of a larger work. There are no Silences or *diminuendo* or slowing down of events that suggest phrase endings within the music, or even to indicate completion of the entire piece of music. Indeed, the final event of the music, consisting of two Quick notes in High Register, was one of the most unusual events in the whole work, as well as being an atypical ending to a complete work. This ending added to the sense that this music was an excerpt from a much larger piece (which remains to be completely heard). This possibility is also supported by one interpretation of the distribution of feature sets across the time domain, which proposes that the music contains an introduction and then one main section of music, which is then to be continued in one or more sections. However, the second formal possibility that the music is a set of four variations seems more plausible based on the visual representation of the feature sets over time and the analytical charts of Attribute Combinations over the Time Domain.

The two events in Event Duration can still be interpreted as anacrusis events, suggesting that this set of variations is not complete, that there are more possibilities to be explored. This is backed up by the knowledge that only some of the possible variations in sounds have been incorporated into this existing music. The range of variation actually present in the music was quite limited. The Piano and Cello were sometimes in very close, or identical, Registers; at other times in quite disparate Registers. The short notes were about 1" long, the long notes were longer than 10", the very long notes I could not define a duration; there were only unisons or semitones, or leaps in similarly timed or adjacent events in the instruments. The only differences in character between *pizzicato* and bowed notes were the timbral resonance and the duration. The bowed notes did not have any

sharp attack, nor any *vibrato*. Neither Sound Production Method was more accented nor emphasised in any other way.

This range of possible ways of making sense of this music is all about technical aspects of the music, and in one sense there are quite fine distinctions between the ideas as they simply preference different aspects of music as an artform. What does stand out and unites these possibilities is that this music does not make sense in relation to any extra-musical idea, such as an external narrative, or testing the capacity of new technological devices to produce music. This is 'absolute' music in all its abstract glory. The fact that there are so many ways to make sense of this music, which is inherent in the contemplation of an abstract object, supports the idea that this is 'absolute music'.

My experience of this music was timeless and immersive. A collection of sounds transported me right into their own nuances and out of any sense of my own time or other reflective thoughts on the music. All the technical ideas that this music contains are in the service of this bigger idea of making music which is purely experiential, which sort of exists outside of time. The sound events in the music seem principally focussed on nuance, on the similarities of the sounds of the two instruments, it has no variations in amplitude, rhythm or meter. There is no way to measure time in this music. Every sound exists in its own right not as part of a larger group. The final sound event, an upward Quick two-note motif, clearly suggests that there is more music to come. It suggests that rather than being a complete work *Durations II* is simply the 'tip of an iceberg'. Superficially, the whole object, but there is a lot more under the surface. Perhaps all the possibilities that have now been laid out in *Durations II* are only an introduction to the music which can now begin!

Because the music sounds so unfinished at the end; because the music introduces only a small range of possibilities in the sounds produced by the combination of instruments and there could be more; because the formal qualities of the music are uncertain as it contains no clearly audible sections, but analysis reveals that it might be an introduction and a single phrase, or more plausibly, the music might be a set of variations; and because this music is quite long while containing so few sound events, but is not boring, as the music continues to draw attention to itself as a

whole without any attention grabbing devices. Because all the ways to make sense of this music are about technical aspects of music as an artform focussing on nuances of sound and time both in the immediate sense of individual sound events and also in the larger formal design; because the music does not refer to any extra-musical events or ideas, or even itself while it is in process, this music performs the idea of music as an abstract intangible time-based artform. The idea of this music is to enable a timeless, experience of unfolding nuances of sound.

Appendix D. *Fuzzy IDEAS* applied to *Concert for Piano and Orchestra* (Cage, 1957-58)

Concert for Piano and Orchestra (Cage, 1957-58) is the music used in this worked example, which demonstrates how *Fuzzy IDEAS* works to discover possible ideas in this music along with the technical aspects of the music, which have stimulated those ideas, using my own experience of listening to this music. The first section provides detail on the information collected prior to listening to the music about prior knowledge of the music and the impact of the title as a framework for listening. The second stage, which is not directly documented in the analysis, is the collection of the qualitative listening observations while listening to the music in real time, while the fourth stage provides details of any problems encountered in the collecting the qualitative listening observations, and details the qualitative listening observations collected for each Reflective and Partially Indeterminate Event. The intermediate stages of the conversion to fuzzy logic entities and the visual representations of the fuzzified data are worked through, until the final Stage 9 draws out the ideas implied by analysis of these visual representations, in conjunction with earlier conjectures which emerged in previous Stages.

Stage 1. Documenting Pre-Listening Pre-Conceptions

The purpose is to identify what the listener brings to this particular listening experience. This section documents various aspects of mental preparation for the listening experience which will both affect and inform the actual experience of the music. This includes considering the possibilities suggested by the title for ideas in the music, along with any preconceptions brought to the listening experience through prior knowledge of the composer or the style of music.

‘Concerto’ in a title conventionally implies a specific range of textures: solo instrument, orchestra alone, or orchestra in simultaneous accompaniment to the soloist, arranged in various possible formal designs. These possibilities include solo piano sections, which either simply alternate with, or dialogue with, the orchestra in contrasting sections. It is easy to gloss over the omission of the final ‘o’ on the word ‘Concert’ in the title of this music, which leads to thinking that this will be a concerto

for piano and orchestra. Yet, even if the conventional title was carelessly assumed, knowing the music was composed by John Cage, it is quite possible that the music itself will be unconventional both in form and content.

Having, however, managed to catch the fact of the missing 'o' leads to speculation about what the title precisely references. There are a number of possibilities. Firstly, 'Concert' could be a modern replacement for 'Concerto', which as stated previously has at minimum, implications regarding texture and possible forms. However, if 'Concert' is intended literally, at face value, this leads to further uncertainty. 'Concert' could be referring to the (conventional) formal style of presentation by performer to audience, where the performer is treated with the utmost respect and there is minimal audience reaction and participation. Alternatively, the title could be referencing the idea of team work, collectively moving towards a goal by acting 'in concert'. This possibility suggests that there won't be only distinctively soloistic piano sections, but rather both piano and orchestra will be unified and move together simultaneously in a concerted manner. Alternatively, acting in concert can mean that each 'voice' remains individual, yet working together to produce a co-operative output.

Leaving aside the interpretation of 'Concert', the title has some clear indications of the timbral world of this work. 'Orchestra' provides a clear pointer towards a large range of instruments across all the strings, winds, brass, percussion, with multiples of the same instrument. However, knowing that the composer is John Cage means anything is possible with the piano. Possibilities range from complete silence to a 'prepared' relatively unpitched percussion instrument. Alternatively, it might just be a conventionally played pitched instrument.

Together, these reflections on the title before listening to the music lead to an amount of uncertainty. I began listening expectantly into the music to hear which possibly would turn out to be true.

Stage 2. Collecting the Qualitative Listening Observations

I used pencil and paper to document qualitative listening observations about the music or my self-aware subjective responses while the music is playing, along with time points at which those qualitative listening observations were made.

My experience of listening to *Concert for Piano and Orchestra* produced 43 qualitative listening observations over 27'40".

Stage 3. Immediate Impressions about the Idea that Makes Sense of this Listening Experience

There is a distinct absence of long virtuosic Piano solos; and the so called 'Orchestra' rarely play as a distinct group. Actually terming the ensemble 'Orchestra' is quite a stretch of the normal sense of the word, as it sounds like a small collection of individual instruments: a chamber ensemble. The simplicity of the Texture, with many Single Sound events of Long Duration focus the listener on the quality of one sound, and then another. The memorable aspects of the music were the variety of sound types produced through different articulations; the predominance of single notes, rather than chords; the long duration of some sound events; the absence of melody; the absence of harmony; the relative absence of the 'Orchestra' as we conventionally know it; the absence of the virtuosic 'soloist'; the recurring Silences which could have been the end of the work but weren't; and the existence of some sound events which could not be identified as to technique or instrument, but were reminiscent of real world sounds and other styles of music. Together this left me with the impression that this music was an exploration of 'colour in sound', designed to highlight the variety of timbral possibilities inherent in instruments, to focus the listener on the qualities inherent in sound itself. In this regard, even the prolonged ending of the work, gave an aural highlight to the Piano as soloist.

Stage 4. Considering this Listener's Experience of Collecting the Qualitative Listening Observations

Any problems arising while collecting the qualitative listening observations are documented here. This stage also provides the detailed qualitative listening

observations which capture thoughts, reactions, memories, or images, that rise to conscious awareness in response to the sound of the music. These cognitive events may arise instead of, or as well as, any observations about technical aspects of the sound of the music.

I used a CD player for the listening test. This enabled the use of the digital timer on the CD player to determine the time points of the qualitative listening observations. Using a CD player also meant a fail-safe alert to the end of the music, in the absence of live performance cues, as the next track would eventually begin playing.

A range of things occurred that did not conform to conventional ideas about music. Unorthodox qualities experienced while listening to *Concert for Piano and Orchestra* arose from several sources. There was no melody, no chords, no harmonic progressions. Primarily the sound events consist of single notes. Many events are pointillist, and very rarely occur simultaneously, so that their individual existence bears little obvious temporal relation to any other event. Some events are clearly grouped through repetition, while others morph from one state to another, such as the sound events, E13 at 14'50" which starts as a String sound and concludes as a Clarinet sound, E15 at 15'50", maintaining constant pitch throughout.

Some sounds did not seem to have originated from a conventional acoustic instrument. Hence, a small number of documented sound events did not have a clearly identifiable instrumental source, which presumably results from an unusual, and hence unidentifiable, playing technique. For example, one sound event, at 14'20", is a series of continuous shrieks, sounding like a baby in distress. I had to remind myself that this work did not contain any electronics or sampled sounds.

There were quite a number of Silence events. The documented Silences towards the end of the music may at first glance appear strange, because attributes not normally associated with Silences, such as Texture and Event Duration, have also been noted for particular Silence events. This documents the effect of the music stagnating into long silences interspersed with a smattering of pointillist sounds.

Table D.1 below, provides the listener's qualitative descriptions of cognitive events and any technical observations associated with those thoughts or insights. The precise details of each of these observations are usually quite different from one

another. This documentation enables comparison of the qualitative listening observations not only within this particular analysis, but should the experiments be replicated, it enables comparison of whether and how other listeners have described similar events. Table D.1 does not list all the qualitative listening observations for the whole of this listener's experience. Rather Table D.1 only details those qualitative listening observations that contain cognitive processing associated with self-awareness of perception, memories and reactions to the sound of the music; moments of focused attention on the music; along with any moments at which the listener has become consciously aware that particular aspects of the sound of this music have stood out. In preparation for the 'fuzzification' of this information during Stage 5, in accordance with the rubric for the method, all documented time points are quantised downwards to the nearest five seconds.

Table D.1. *Concert for Piano and Orchestra*: List of Cognitive Events

Event Number	Time Point	Event Description
E0	0'00"	Piano and Orchestra play simultaneously. High level of interest at the beginning of the music, which continues throughout much of the music, to discern which of the alternative meanings in the title are actually presented in this music: what is the relationship between Piano and Orchestra?
E1	1'30"	End of a Sustained Brass note, which rose to awareness only as it ended. There was no clear beginning to this note as it emerged out of a jumble of other events, hence uncertainty as to its commencement.
E4	4'30"	Awareness that the 'Orchestra' has returned but this time without the Piano
E6	5'50"	Bass pizzicato. Sounds like a jazz motif because of the sound source, playing technique and rhythm.
E8	8'40"	The first appearance of String Tremolos at a louder Amplitude than the previous sound events served to draw me back into the music.
E9	11'30"	Momentary Silence. Wonder if this is the end of the movement, yet aware that not enough time has elapsed for the work to be finished, but this seemed like a natural end point. It became apparent when the next sound event occurred that the music was continuing.
E10	12'40"	Long notes in strings had died away to silence. Again wondering if this time it really was the end of the movement.

Event Number	Time Point	Event Description
E11	13'40"	A Sustained Brass note has emerged out of the other sounds occurring at this time point.
E12	14'20"	Unidentifiable Sound Source to produce an effect like a baby crying. Was completely surprised by this sound of continuous shrieks, and could not identify any instrument. I had to remind myself that this work did not contain any electronics or sampled sounds.
E13	14'50"	Unusual timbre (string being scraped very slowly). This was clearly the sound of a String instrument being bowed so slowly that the sound was very rough and broken, losing all melodic associations.
E15	15'50"	The conclusion of a 20" sustained note that began as a Stringed instrument and ended as a Clarinet. This event was remarkable for how the timbre morphed from one to the other while Pitch and Amplitude remained constant.
E18	16'30"	Very unusual sound: a very short 'Yip'. Difficult to identify the Sound Source, because the event was so short, and so uncharacteristic of any of the instruments. Ultimately concluded it was Clarinet being played with unusual technique, because none of the other instruments could have produced this sound.
E19	17'10"	A Sustained event with an Unknown Sound Production Method and an Unidentifiable Sound Source.
E20	17'30"	As the previous sound event draws to an end, it is still not possible to identify the Sound Source of this sustained event, although it is possibly a wind instrument.
E21	17'50"	A clear Flute Event. This was the first time I had been aware of the Flute as part of the ensemble as it had not previously been present as an identifiable Sound Source.
E22	18'40"	Unusually prolonged Sustained String glissandi moving continuously up and down the registers (like sirens).
E23	19'00"	Awareness that somehow the Sound Source had changed from the previous String glissandi into a single Sustained Brass event.
E25	19'40"	Unidentifiable sounds. Despite much reflection I could not identify this sound, which did not resemble any external sound that I could identify.
E27	20'40"	Piano stands out very clearly above any other Sound Source, playing very regular, distinctly articulated notes.
E28	20'50"	The conclusion of a long section featuring the Piano, which continued to stand out among the other Sound Sources.

Event Number	Time Point	Event Description
E31	22'30"	Silence: is this the end of the music? There have been other moments of Silence among the pointillistic sounds, but this one stands out as a clear Silence event.
E33	23'10"	A long Silence: perhaps this is really the end of the music?
E36	24'20"	Another long Silence: perhaps the end of the music? I was aware that much time had elapsed since the beginning of the music. I was even more convinced that this must be the end of the music.
E38	25'20"	Another long Silence between pointillistic events. The other sound events occurring around this Silence event seemed pointillist, as they did not seem to be related to each other, even though some of these events were not just Single Sounds but delicately textured groups of sounds. This was another recurring long Silences between events which had me continuously wondering if this was the end of the music.
E40	27'10"	At this point I was bored with the music, and was no longer interested in paying attention, as the preceding Silences interspersed with pointillistic material just seemed an aimless prolongation devoid of further interest. There seemed to be no logic or rationale for their existence that I could impute.
E41	27'30"	Sustained Single Piano note Emerges out of the preceding Silences and Dies Away. This note caught my attention because it was so pure in execution, with no articulation or other technique. It was prolonged only by the natural resonance of the instrument, so that it slowly died away, without being re-articulated or replaced by another event.
E42	27'40"	A prolonged Silence, the longest in the work so far. It seemed as if this might really be the end, because nothing else was happening, but I was still somewhat Uncertain because of the previous Silences the range of sound events which had occurred in the music, so continuation was a real possibility. However, the CD moved onto the next track so that settled the matter.

Stage 5. Converting the Qualitative Listening Observations into Fuzzified Data.

The purpose of this stage is to use fuzzy logic principles to classify the qualitative listening observations into my hierarchy of fuzzified data by means of the coding taxonomy set out in Chapter 5. The coding taxonomy provides a consistent and systematic way of organising and categorising the qualitative listening observations into fuzzy logic entities. The resulting hierarchy of fuzzified data describes each qualitative listening observation at two different levels of detail: attributes and fuzzy feature sets. This stage also contains details of specific problems, if any, encountered in the conversion process for this specific music.

Both the title and my own musical training regarding the definition of 'Concerto' kept on pulling me towards Texture as an important attribute. This starting point was challenged by my experience of this music. It quickly became evident that describing sound events with labels such as Piano Solo or Orchestra is irrelevant to the sounds as they occurred. Additionally, there was no melody, nor apparent accompaniment, nor contrapuntal voices. Mostly the Texture is pointillist: each sound event occurs in isolation except for occasional, apparently accidental, overlaps between one sound event and the next. This suggests that Texture as a separate attribute is needless, especially since the most complex Textures rarely occur, yet many of the qualitative listening observations remark on this aspect of the sound. Ultimately, including Texture highlights the absence of interwoven voices, these being replaced by Single Sounds and other simple Textures.

In this music, individual instruments are frequently clearly identifiable, but sometimes they sound together in larger groups: specifically, Brass, for example E5 at 4'50", and Strings, for example E8 at 8'40". Selecting Sound Source as a distinctive attribute, rather than individual instruments, then allows each instrument or group of instruments to become a separate feature set. This arrangement also enables the inclusion of those sounds for which the Sound Source cannot be clearly identified.

In this music there are some very unusual sounds, for example E12 at 14'20", E19 at 17'10", E20 at 17'30" and E25 at 19'40". It is impossible to determine the Sound Source for these four sound events. For instance, E12 at 14'20" sounds like a baby

crying. Perhaps it was a baby crying in the audience, or perhaps it is a conventional acoustic instrument played in a very unconventional way. In fact, so unconventional is this sound, it was impossible to determine which instrument it might have been. I resolved this by categorising the four events in the feature set of Unclassifiable Sounds in the attribute of Sound Source, because this is the simplest and most transparent way to deal with these completely illogical sound types. All sounds then are completely identifiable as belonging to a particular feature set of Sound Source.

Sound Production Method is included as an attribute distinct from Sound Source which enables Register, Amplitude and Event Duration to remain as independent attributes, because Sound Production Method exists in an entirely different domain than these three attributes. Although I was unable to identify the precise Sound Source for some events, the sounds themselves still have Amplitude, Duration, and Register. Independence of attributes means that these sound events have an equal place in these domains, rather than being overlooked or treated in a special way.

Positioning Sound Production Method as an independent attribute in addition to Sound Source easily incorporates the range of playing techniques which are incorporated into this music, such as *glissandi* and *tremolo*. *staccato* in Flute and *pizzicato* in Violin have some small differences due the different mechanics of the instruments, but most importantly have similar aural effects of relatively soft amplitude, brevity, and temporal detachment from the next sound event. Returning momentarily to traditional score notation, this similarity is recognised in the symbols used to denote techniques specific to individual instruments which have similar aural effects. Examples include the trill sign (tr~), which in pitched instruments denotes rapidly alternating neighbour notes, but is also used in untuned percussion to denote rapidly alternating hand strokes to produce rolls, while unmeasured tremolo (≡) denotes rapidly repeated identically pitched notes for many instruments. Thus grouping these similar concepts into an attribute of Sound Production Method is not an entirely new concept. However, despite similar score notation, individual instruments typically have their own nomenclature for specific playing techniques. I have chosen the most transparent term as a label for the fuzzy feature sets of Sound Production Method.

The fuzzy entities I selected for classifying technical attributes and features are shown in Table D.2. This table shows the technical details in the qualitative listening observations organised into attributes and then feature sets. This classification is designed to cover the sounds of this music in the most comprehensive yet efficient way. These attributes and feature sets will be used to represent this listening experience in visual form.

Table D.2. *Concert for Piano and Orchestra*: Technical Attributes and Feature Sets

Attribute	Feature Sets		
Time	The smallest time interval between recorded events is 10"		
Amplitude	Loud Relatively Loud	Getting Louder Dying away	
Register	Very High High	High Mid Mid	Low Mid Low Bass
Event Duration	Quick Detached	Regular Getting Longer	Long Sustained
Texture	Polyphony: interactive similar groups of sounds Homophony: two groups with some distinctive technical qualities Monophony: groups of single notes or chords of the same sound type Alternating Sounds Repeating Sounds Single Sound Events		
Sound Production Method	Pizzicato Regular	Glissando Tremolo	Scrape Unknown
Sound Source	Piano Strings	Brass Clarinet	Flute Unidentifiable

Stage 6. Constructing Visual Representations of the Fuzzified Data

The purpose of this stage is to report the fuzzified data in a visual format which directly represents various aspects of this personal experience of the music. The visual representations are constructed from the fuzzified data for each sound event at both attribute and feature set level. The quantisation interval selected for mapping the fuzzified data into the visual representations is based on the smallest time interval between the quantised time points, which here is five seconds.

The fuzzified data in time series at the attribute level gives the single most complete overview of the listening experience. This visual representation is provided in Figure D.1 below.

By contrast, the fuzzified data at the feature set level across time gives the most detailed visual representation of the listening experience. This level of detail requires multiple visual representations which are presented in Figures D.2-D.9 below.

a. Attribute Combinations across the Time Domain

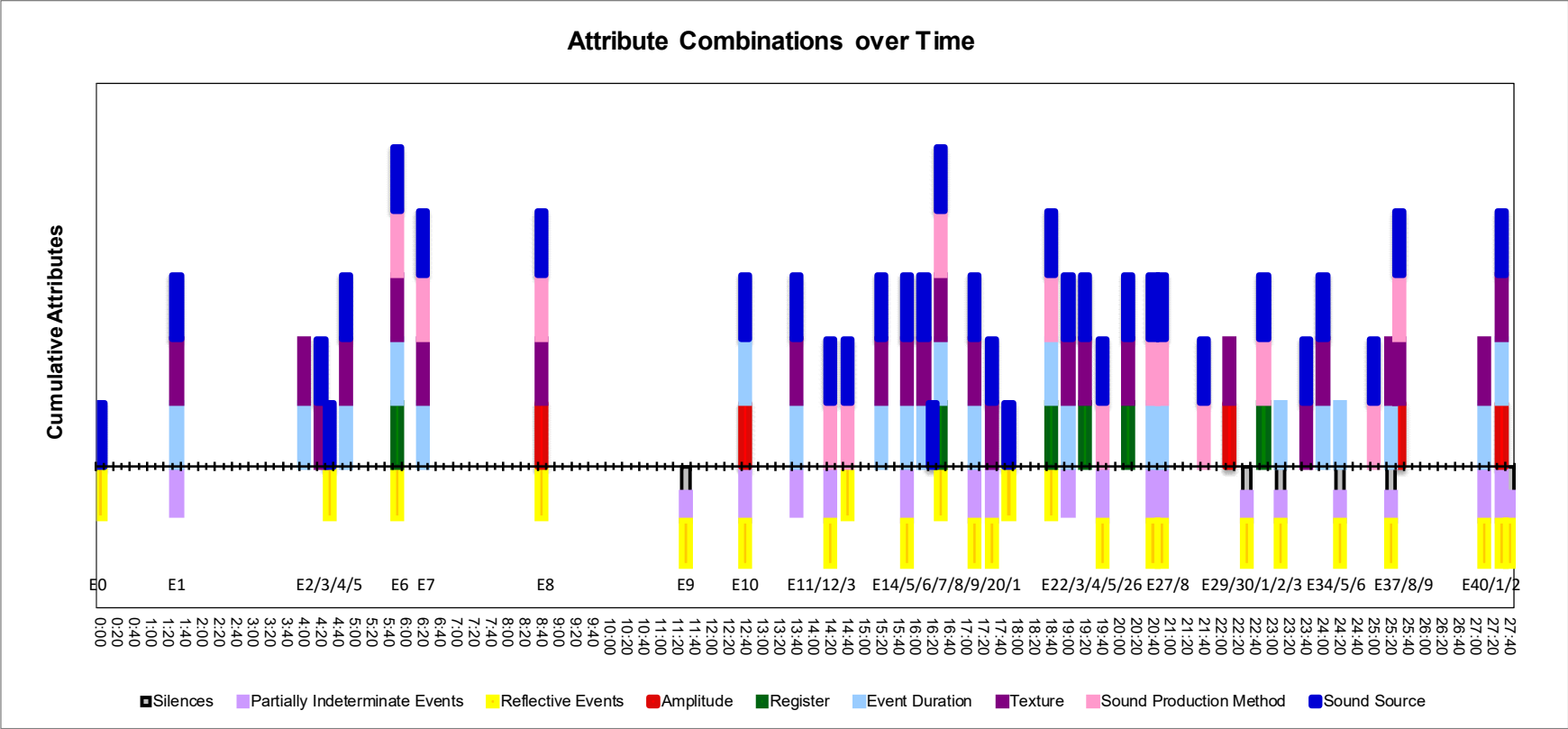


Figure D.1. *Concert for Piano and Orchestra*: Attributes across the Time Domain

b. Fuzzy Feature Sets across the Time Domain

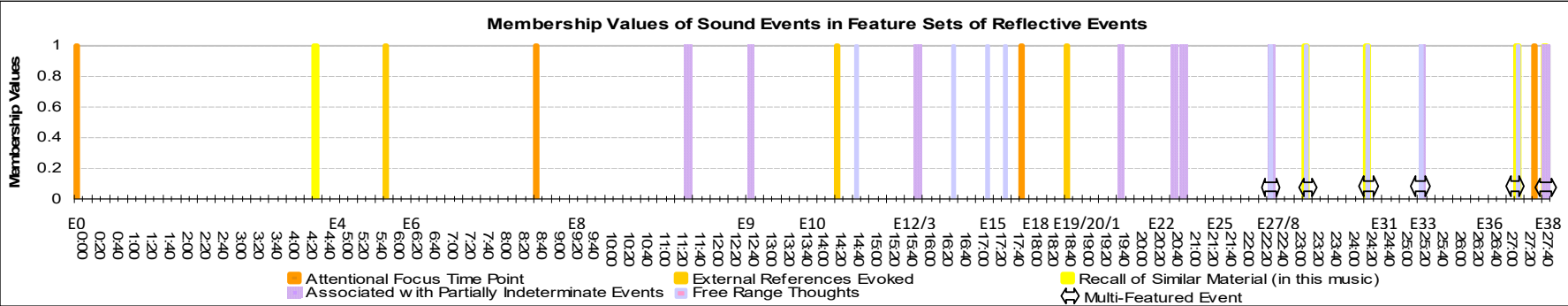


Figure D.2. Concert for Piano and Orchestra: Feature Sets of Reflective Events over Time

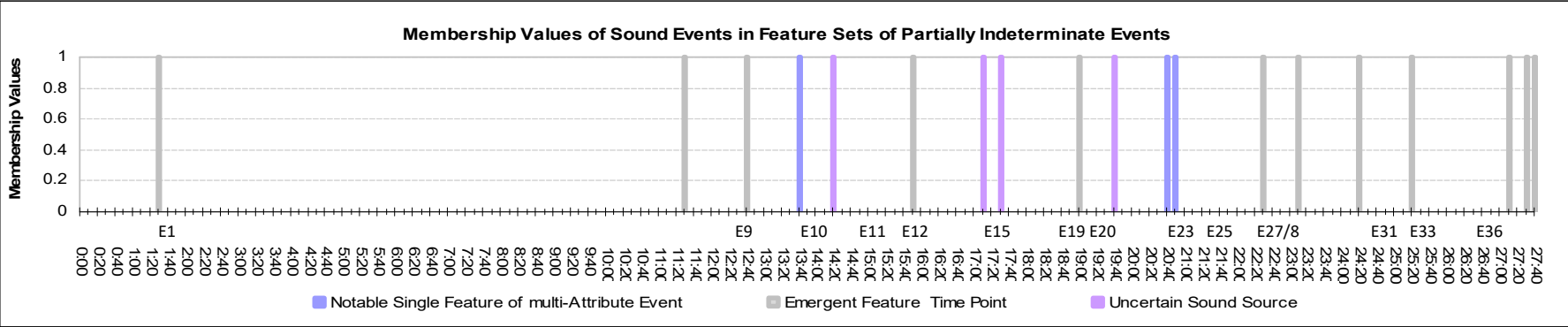


Figure D.3. Concert for Piano and Orchestra: Feature Sets of Partially Indeterminate Events over Time

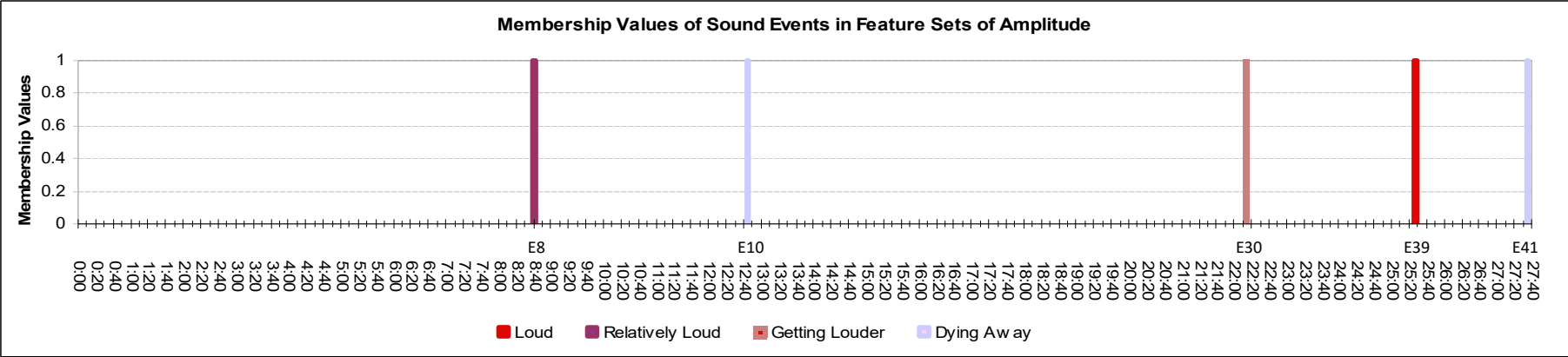


Figure D.4. Concert for Piano and Orchestra: Feature Sets of Amplitude over Time

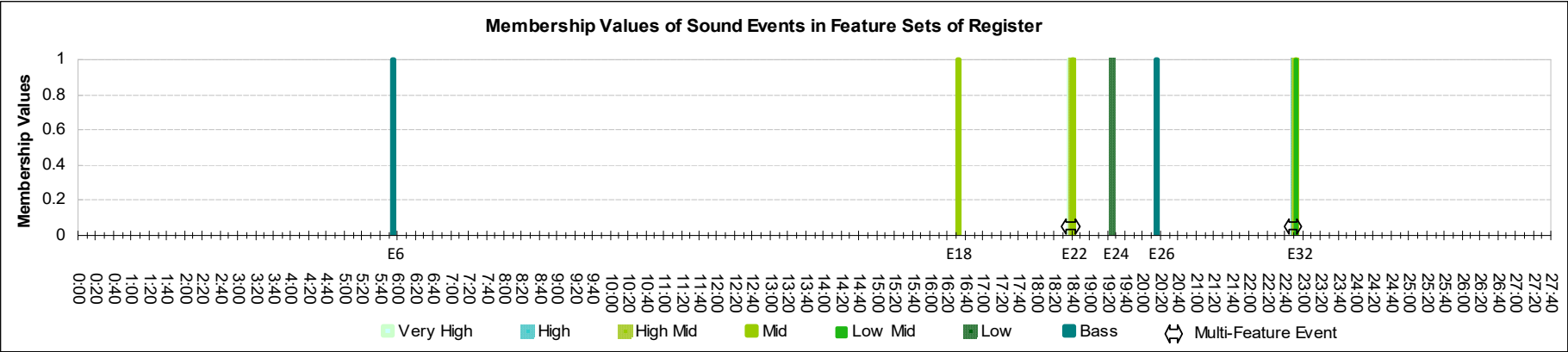


Figure D.5. Concert for Piano and Orchestra: Feature Sets of Register over Time

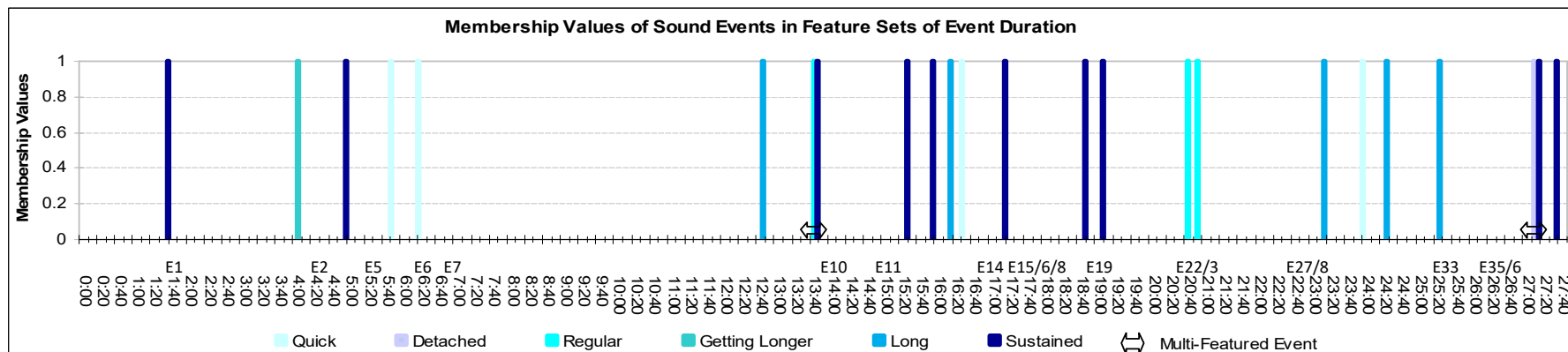


Figure D.6. Concert for Piano and Orchestra: Feature Sets of Event Duration over Time

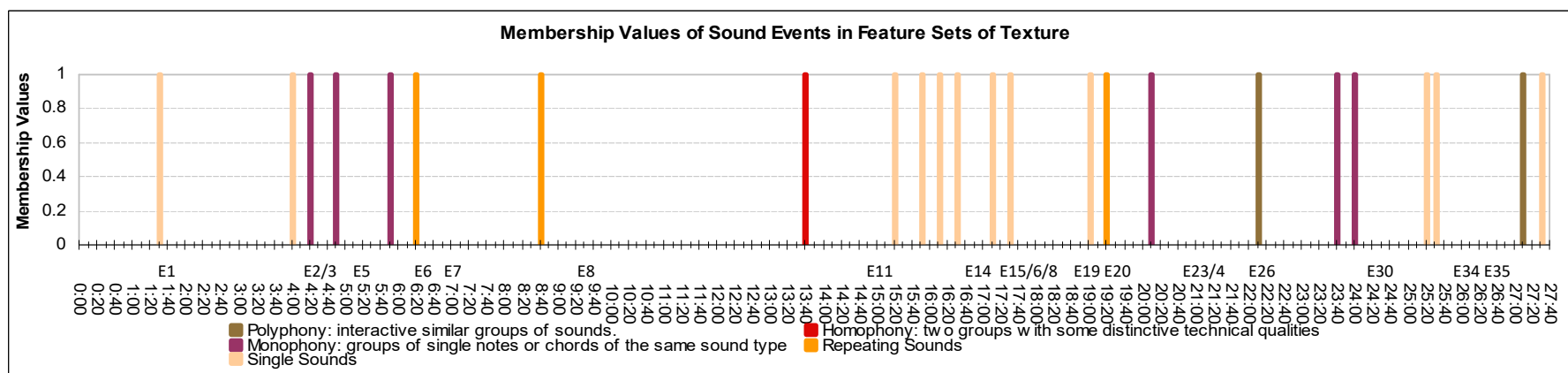


Figure D.7. Concert for Piano and Orchestra: Feature Sets of Texture over Time

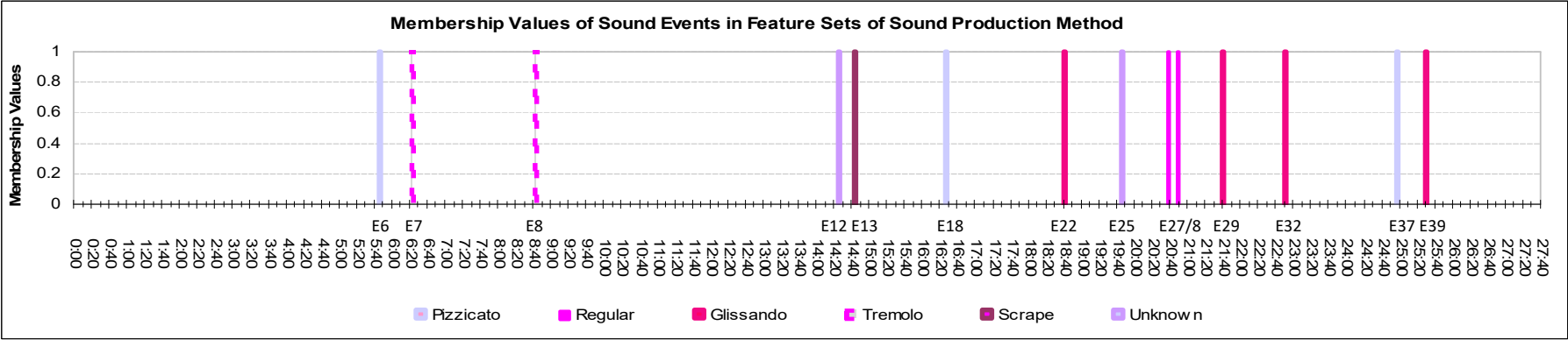


Figure D.8. Concert for Piano and Orchestra: Feature Sets of Sound Production Method across Time

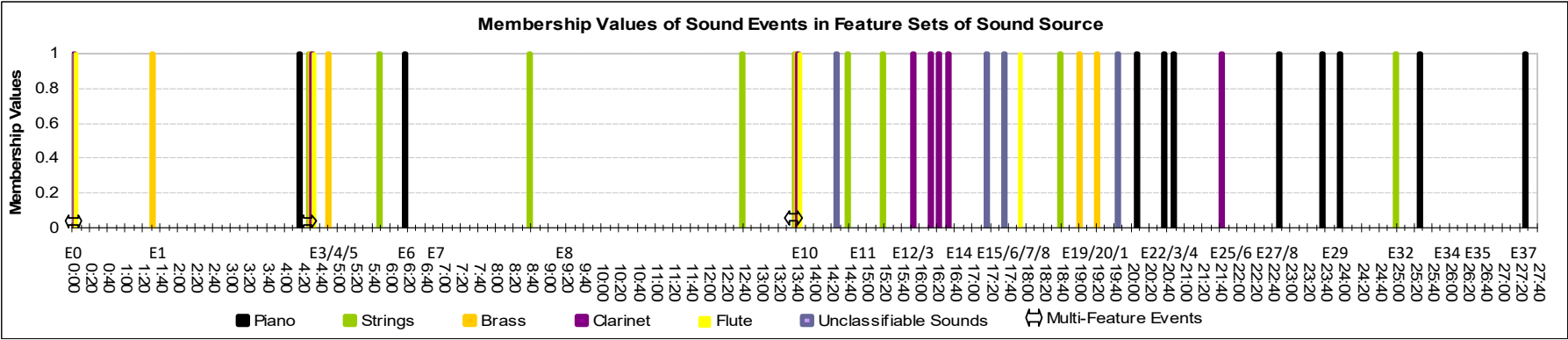


Figure D.9. Concert for Piano and Orchestra: Feature Sets of Sound Source across Time

Stage 7. Analysing the Frequency of Fuzzy Entities in the Visual Representations

This stage summarises the information conveyed by the visual representations to draw out those attributes and features highlighted in this single experience of the music. These significant occurrences imply that these particular qualities have been emphasised by the composer. Relative frequency of attributes and feature sets also indicates the amount of variation between individual sound events.

a. Frequency of Attributes

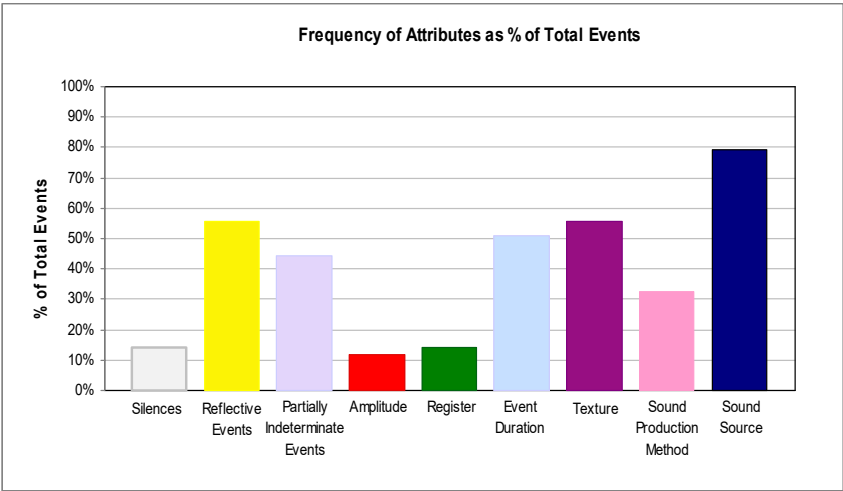


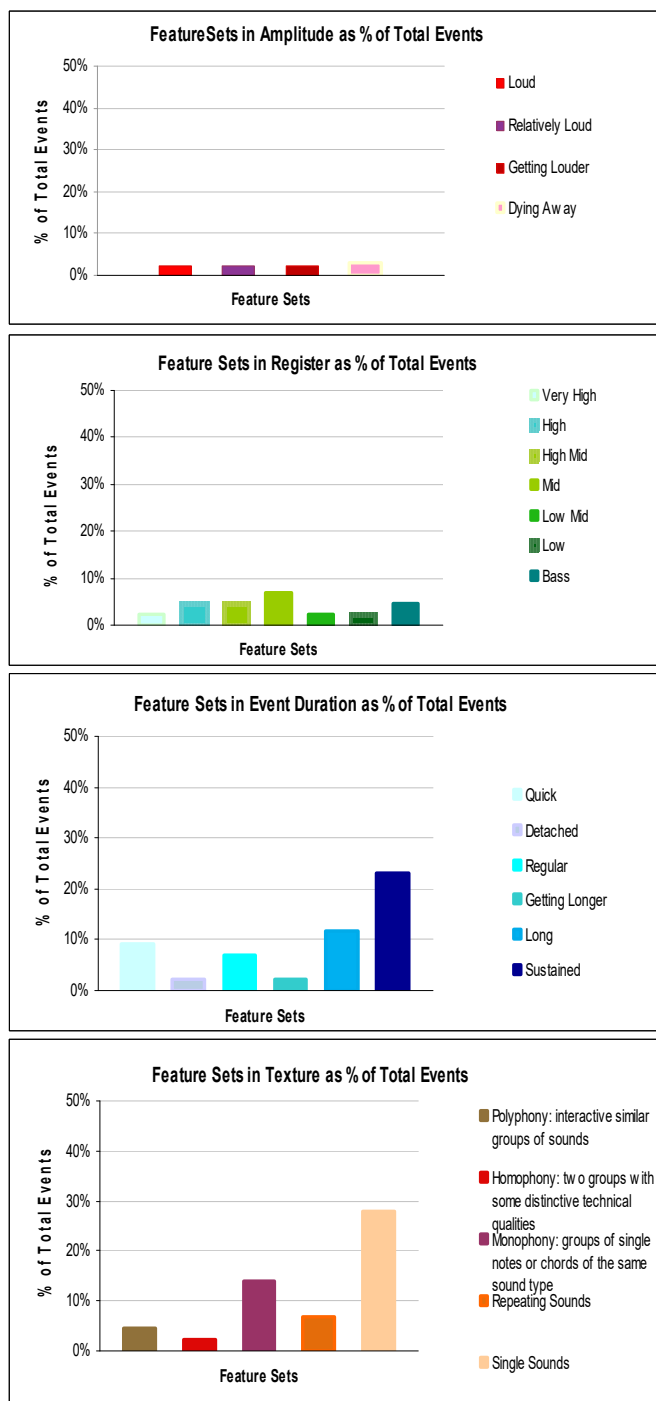
Figure D.10. *Concert for Piano and Orchestra*: Frequency of Attributes

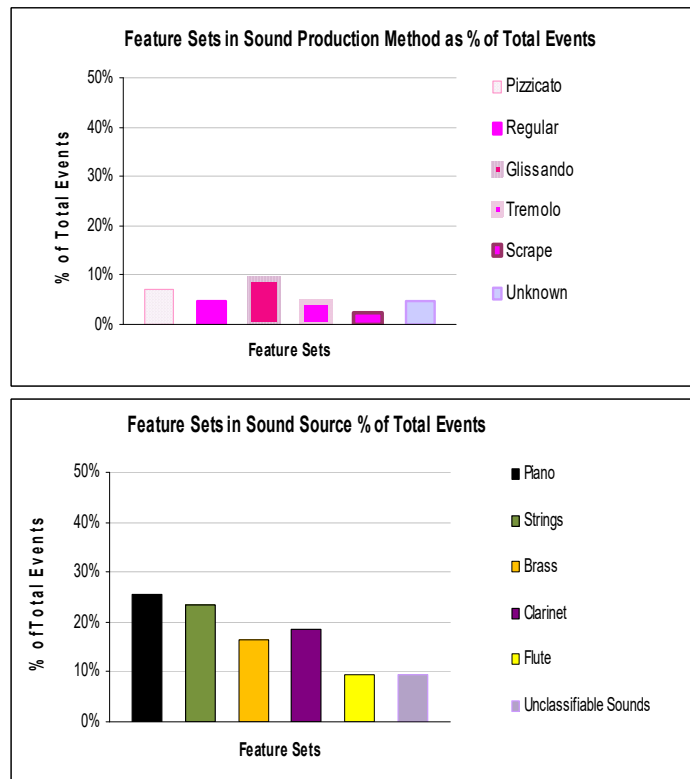
Sound Source is documented for 79% of all events in this music, 55% of Events include Texture, and 51% include Event Duration. Sound Production Method is documented in 32% of total sound events. Both Register and Amplitude are relatively infrequent at 14% and 11% respectively. This indicates that Sound Source, Texture, Event Duration, and Sound Production Method are useful attributes that specifically characterise this music. Reflective Events are incorporated in 55% (24 out of the total 43) sound events, while 19 (44%) events are Partially Indeterminate Events.

b. Frequency of Sound Events in Technical Feature Sets

Each attribute is broken down into its constituent fuzzy feature sets. FigureD.11.

Concert for Piano and Orchestra: Frequency of Technical Feature Sets below provides a set of histograms, each of which shows the proportion of total sound events included in each individual feature set within an attribute.





FigureD.11. Concert for Piano and Orchestra: Frequency of Technical Feature Sets

The most significant Features in this music occur across a number of attributes. Emergent Feature Time Points in the attribute of Partially Indeterminate Events occur in 12 (27%) of 43 total events. Single Sound Events in the attribute of Texture also occur in 12 (27%) of 43 total events, while Piano and Strings in the attribute of Sound Source are not far behind at 25% and 23% respectively. Sustained Event Duration also occurs in 23% of total events, while in the attribute of Sound Source, Clarinet and Brass have been documented for 18% and 16% respectively.

Although Sound Production Method has been documented for 32% of events, the most frequent of the six fuzzy feature sets occurs in only four (9% of total) events. Similarly, Register is documented for 27% of total events, in seven fuzzy feature sets, of which the most significant is Mid, which accounts for three events in total. Amplitude is relatively infrequent, documented for only five (11% of total events), of which the most frequent is Dying Away at 4% of total events. In fact Amplitude is less frequent than Silence events documented six times (14% of total events).

c. Frequency of Feature Sets of Partially Indeterminate Events

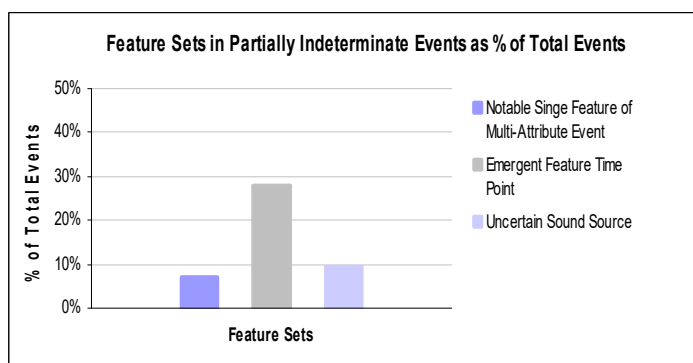


Figure D.12. Concert for Piano and Orchestra: Frequency of Feature Sets in Partially Indeterminate Events

The highest ranking Feature is Emergent Feature Time Point, which is included in 28% of individual event descriptions.

d. Frequency of Feature Sets of Reflective Events

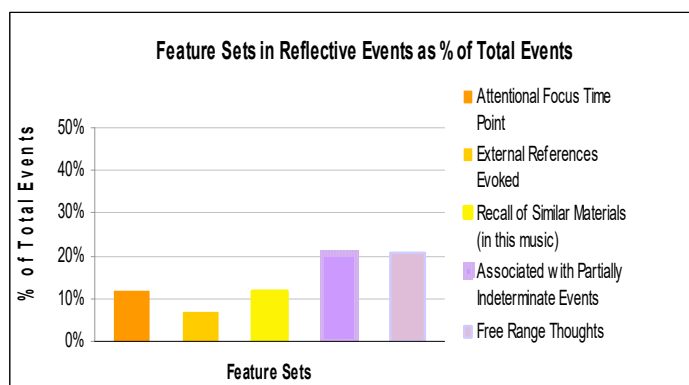


Figure D.13. Concert for Piano and Orchestra: Frequency of Feature Sets in Reflective Events

Reflective Events were recorded for 55% of total events, dispersed over five fuzzy feature sets. Only 5 events (11% of total events) serve to Focus Attention, 7% Reference sound worlds outside of this music, and another 11% Recall Similar Materials in this music, yet 20% of total sound events include Free Range Thoughts, and another 9 events (20% of total sound events) were associated with the perception of Partially Indeterminate Events.

e. Frequency of Attribute Combinations

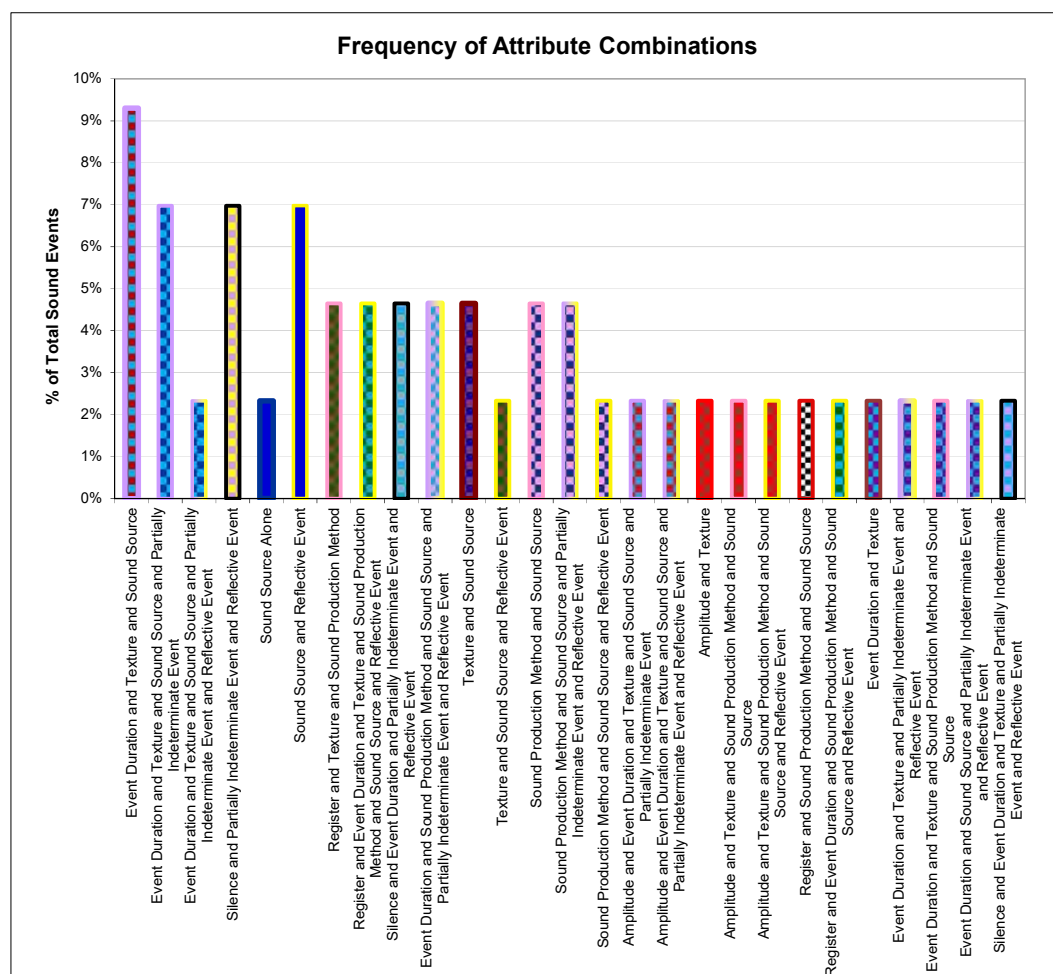


Figure D.14. Concert for Piano and Orchestra: Frequency of Attribute Combinations

There are 27 different Attribute Combinations in this music. There are three events that include Partial Indeterminacy as well as Event Duration, Texture, and Sound Source. An additional four events contain the preceding attributes without being Partially Indeterminate. Apart from these seven (16%) similar events, there are three (6%) Attribute-identical events which consist of Silence Event and Reflective Event and Partial Indeterminacy, along with another three events (6%) which are simply Sound Source and Reflective Event. There are seven Attribute Combinations, which each occur twice during the course of this music. Together all these repeated combinations constitute 63% of events. The remaining 37% of total events contain an additional 16 different combinations

In *Concert for Piano and Orchestra* the most complex events could have a maximum of six technical attributes excluding Reflective Events, Partially Indeterminate Events and Silences. There are two sound events that contains five attributes.

f. Frequency of Transition Pairs

Reflective Events are included in one or both sound events of 37 (88%) Transition Pairs, while 26 (62%) Transition Pairs include a Partially Indeterminate Event.

Each of the 42 Transition Pairs occurs only once in the entire experience of this music. There is one Attribute-identical Transition Pair in the entire piece of music, E27-E28 at 20'40"-20'50". This repetition certainly stands out because of through immediate repetition among a sea of variation.

In *Concert for Piano and Orchestra*, two events preceding Silences include Amplitude and Texture, E8 at 8'40" which precedes the Silence Event E9 at 11'30"; and E30, at 22'10" which precedes the Silence E31 at 22'30". However, these two events differ significantly as E8 is more complex, containing the additional attributes of Texture and Sound Production Method. The remaining four Silence events all occur at very short time intervals after E31 at 22'30", preceded by sound events with quite different Attribute Combinations.

Table D.3. *Concert for Piano and Orchestra*: Repeated Transition Pairs at Attribute Level

This table is empty because each of the 42 Transition Pairs is different from each other.

Stage 8. Analysing the Time Structure of the Visual Representations

The second type of analysis on the fuzzified data explicitly focusses on visual analysis of the time-patterning of attributes, features, and Silence events. This is achieved by constructing a set of analytical charts from the time point visual representations. Each analytical chart addresses a single aspect of the time point representations of the fuzzified data.

a. Time Structure of Attributes of Silence Events

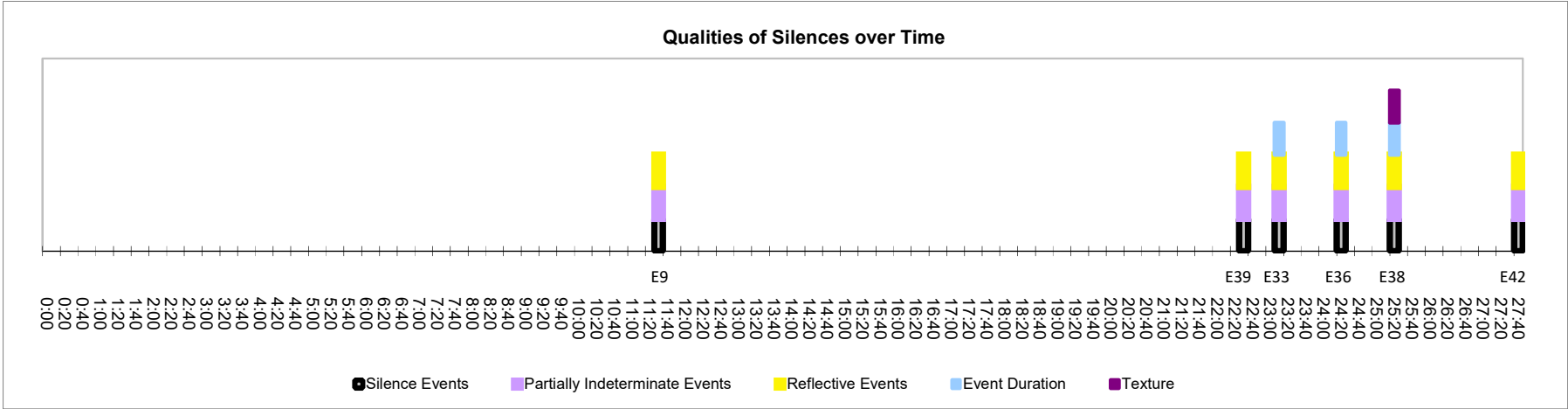


Figure D.15. Concert for Piano and Orchestra: Silences and their Qualities over Time

This chart shows is that not all Silence Events are identical. Some are Uncertain in the sense that it is not possible to know at the time of hearing what this absence of sound implies. Possibilities range from the end of a section to the end of the entire piece of music. Alternatively, the previous sound event has such a gradual diminution in Amplitude that it is not possible to know when the Silence actually started. These possibilities sometimes generate Reflective Events as the listener attempts to make sense of each Silence Event. Indeed the Multi-featured Reflective Events predominantly occur during this time, which indicates how much these Silence events impacted on the conscious cognition of this music. However, these Silences occur at such varying times in the context of the other sound events that it becomes more and more difficult to distinguish their purpose and hence cognitive responses change as the music continues. A particularly unusual Silence event is E38 at 25'20", which has also been documented with Texture. Yet it is precisely because of the surrounding Textures, and the duration of these Silences that they particularly stood out in the listening experience, but at this time point there was uncertainty about whether this event was a Silence or simply part of the surrounding Texture.

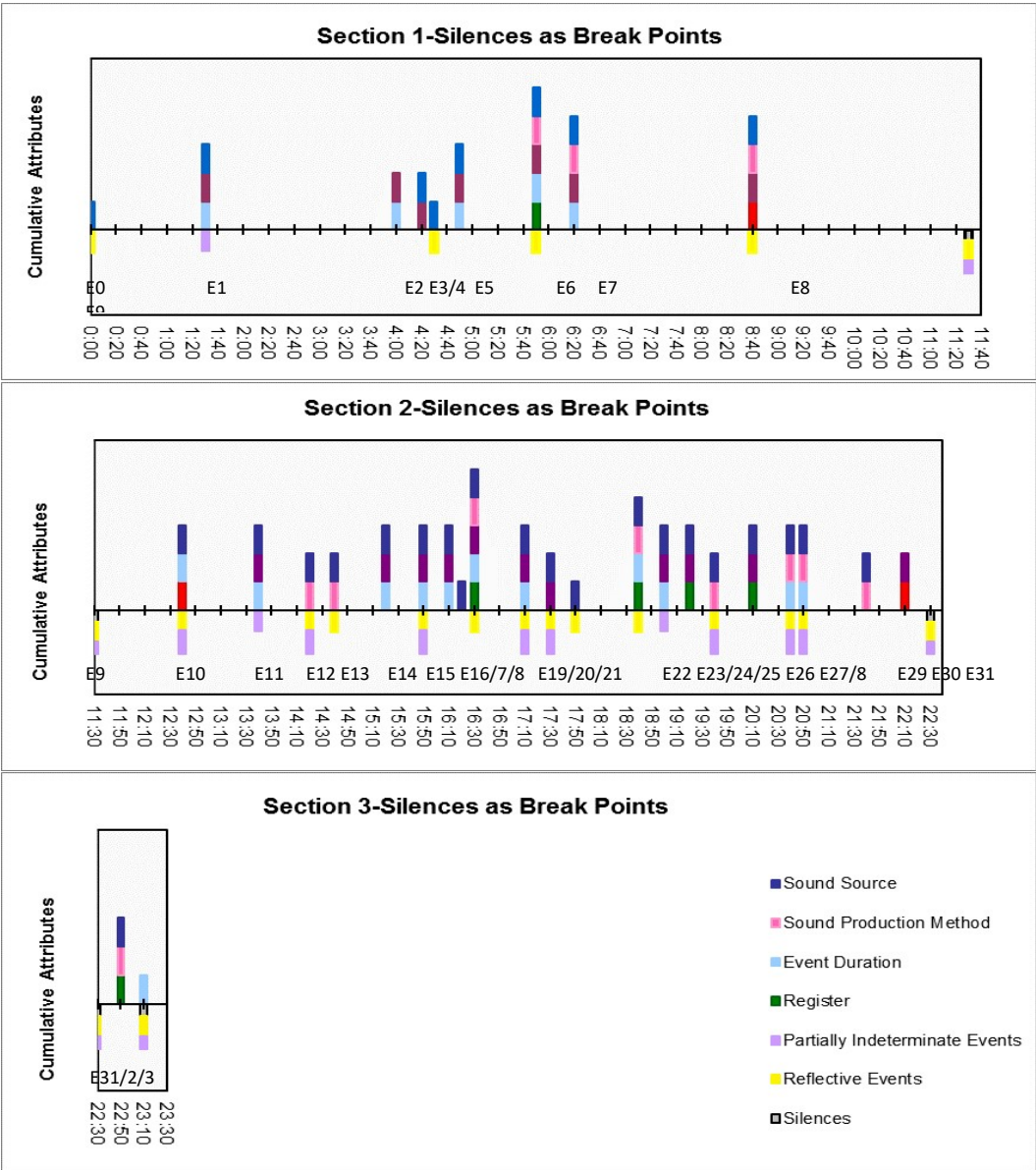
In this music there are six documented Silence Events. The Silence Events are clumped around 22'30" to 24'00"; although one occurs much earlier, E9 at 11'30"; and there is another at the end of the music, E42 at 27'40". The first of these is E9 at 11'30" and the second is a fuzzily similar time interval of 11'00" later, E31 at 22'30". The final five Silence Events all occur between E31 at 22'30" and the final Silence event, E42 at 27'40", a total interval of 5'10".

These final five Silence events have an interesting trajectory whereby they become more complex. This seems a contradiction in terms as it would generally be thought that Silences are just Silences. Particularly notable is E38, at 25'20", which has been documented with the attribute of Texture. Although apparently illogical, this attribution shows the uncertainty caused by the nature of the other events occurring at this time. E38, at 25'20", is a long Silence among pointillistic and apparently unrelated sound events. Some of these sound events were not just discrete single sounds but were instead delicately textured groups of sounds, which also include short silences. The nature and timing of E38 raised questions about its purpose, as it seemed to signal the end of the music, but it could still be part of the delicate

Texture of the surrounding events, with more pointillistic sounds to come. The documented Silences were thus Emergent: becoming notable in their own right only after they had continued for some time. However, overall this large number of Silence events towards the end of the music, had a stagnating effect.

b. Sectional Segmentation by Silence Events

This part of the analysis explores the sectional structure where the duration of each section is determined by the timing of Silence Events. The overall duration of each section and the attributes of events in each section are shown in Figure 2 below.



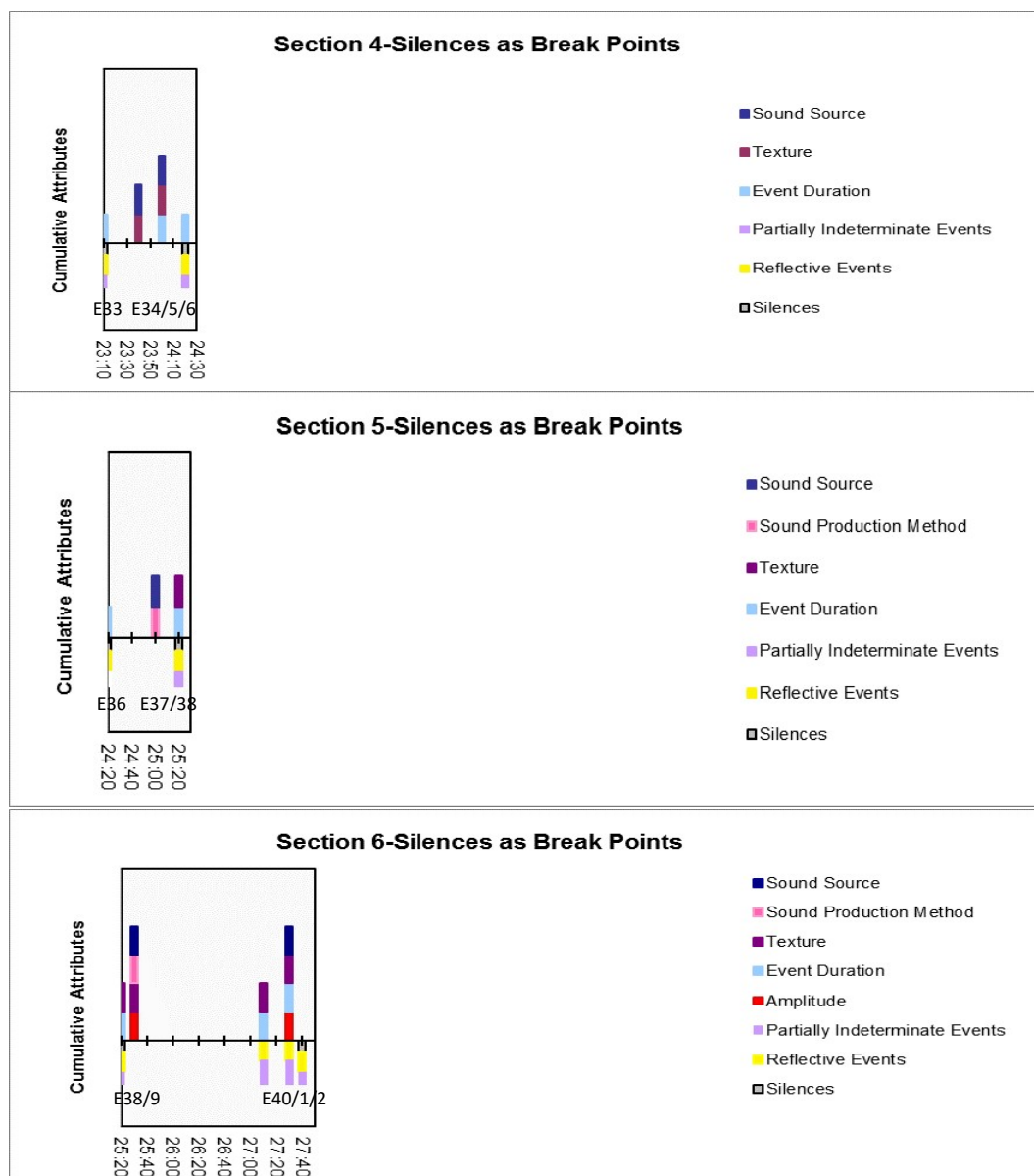


Figure D.16. Concert for Piano and Orchestra: Segmentation using Silence Events as Break Points

All the sections are different in content from each other, although there are some durational similarities, particularly between Sections 1 and 2, which are about 11'30" minutes in duration each, covering around 80% of the entire music. Sections 3 and 5, which are less than one minute in duration, contain one sound event each, while Section 4 is twice the length of Sections 3 and 5 and contains two. Section 6 is between these extremes, being 2'20" long, contains three. Sections 3 to 6 together cover the remaining 20% of the music.

Sections 1 and 2 are of similar duration and similarly marked by complex sound events after an initial period of very little activity. The occurrence of similar events about half way into Section 1, E6 at 5'50", and just over a third of the way through Section 2, E18 at 16'30", is noticeable, as is the occurrence of Amplitude in the final sound event of each section. However, the timing of these Amplitude events in relation to the endpoint of each section is considerably different, as the Amplitude event E8 at 8'40" occurs well before the Silence event which marks the end of this section, while in Section 2 the Amplitude event occurs at E30 at 22'10", very close to the Silence event. Yet the biggest difference between the sections is that, after the repeated very slow opening, the gaps in Section 1 are filled with events in Section 2.

Section 3, which although very short is dense in activity, while becoming less complex over time, fills in the gap, i.e. the time interval in the opening of Section 2 in which no events were recorded. Section 4 is nearly twice as long as Section 3, but opens and closes with Silence events which have a documented Duration, as well as being more focussed on Texture than Section 3, which does not contain any information regarding Texture.

Section 5 is fuzzily the same duration as Section 3. However, Section 5 is of similar shape to Section 4, becoming more complex as the events unfold, even though it contains only one sound event, similar to Section 3. The complexity arises as the nature of the final Silence Event is affected by the Texture of the sound events which occurred before this Silence event.

Section 6 continues the gap-filling but in reverse, with the addition of an early space of no activity equal in length to the whole of Section 5, before concluding in a very similar way to Section 2 with complex sound events which both include Amplitude, although the final Amplitude Event of Section 2 is Loud, whereas in Section 6 it Dies Away, similar to the opening Amplitude Event of Section 2.

c. Event Complexity over Time

This section shows where both the most complex events and the most simple events lie on the Time Domain. Figure *Concert for Piano and Orchestra: Max-Min Technical Attributes across Time* below summarises Figure D.1: Attribute Combinations over Time to show those sound events which have the most and the least technical attributes, i.e. those attributes apart from Reflective Events and Partially Indeterminate Events. Figure D.18. *Concert for Piano and Orchestra: Partially Indeterminate Events across Time* below summarises the configuration of Partially Indeterminate Events, to show the distribution and amount of uncertainty over time. These events contain some uncertainty regarding their definition, in both senses of the word: boundaries are vague, or there is difficulty with sound source identification. Partially Indeterminate Events are by definition more complex than other sound events because of this uncertainty.

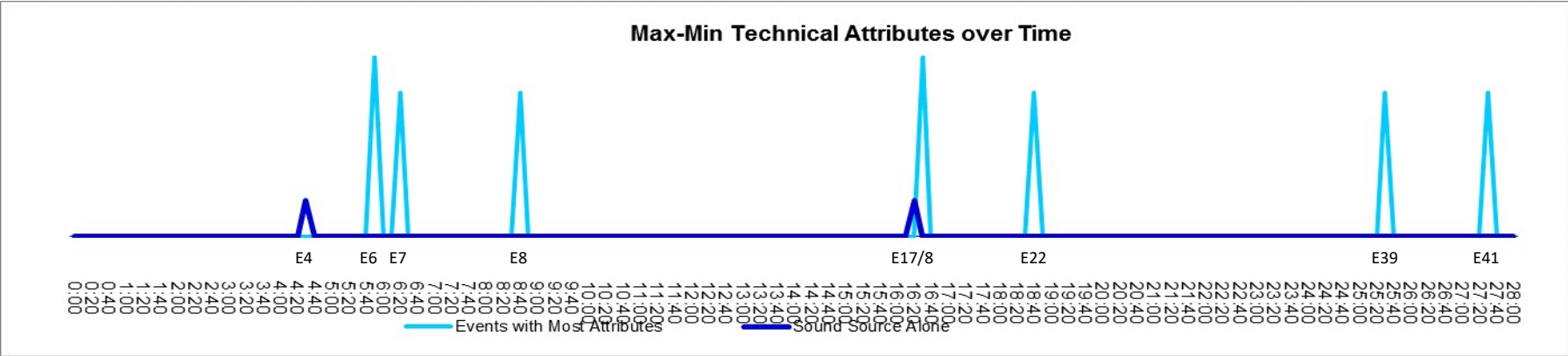


Figure D.17. *Concert for Piano and Orchestra*: Max-Min Technical Attributes across Time

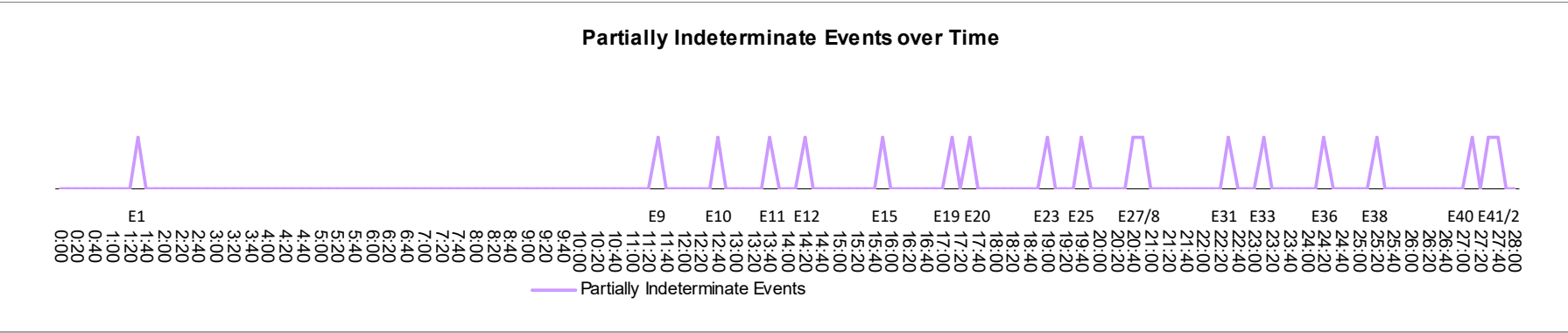


Figure D.18. *Concert for Piano and Orchestra*: Partially Indeterminate Events across Time

The maximum number of attributes possible for any sound event is six excluding Reflective Events and Partially Indeterminate Events. There are two events which include five technical attributes, E6 at 5'50", and E18 at 16'30". These two sound events are identical at attribute level, containing Register, Event Duration, Texture, Sound Production Method and Sound Source.

There are five events which include four technical attributes. These events show variation and repetition in the combinations of attributes, although two are Attribute-identical, E8 at 8'40", and E39 at 25'30".

However, looking further into the time patterning of events, the most complex events occur in three groups, fairly evenly spaced over the time domain. The first group begins with E4 one of two single-Attribute events at 4'30", and concludes about four minutes later with E8 at 8'40". The second group begins with the other single-Attribute event, E17 at 16'20", and concludes with E22 at 18'40". The third group begins with E39 at 25'30" and concludes with E41 at 27'30". The second and third groups begin eight minutes after the previous group, and each successive group is a briefer, collapsed version of the previous group. While the final group begins with the same Attribute Combination that concludes the first group.

Figure D.18. *Concert for Piano and Orchestra*: Partially Indeterminate Events across Time above shows that Partially Indeterminate Events, with one exception, E1 at 1'30", occur consistently from E9 at 11'30", although at time intervals varying from 30" to 1'30" until the end of the music. Even the final event, a Silence Event is Partially Indeterminate, reflecting the uncertainty built up by all the preceding Silence Events. This suggests that the time intervals of 30", and its triple 1'30", are significant in the construction of uncertainty in this music.

Together these two charts show that each dimension of documented complexity and documented uncertainty show quite different temporal designs. Neither aspect of complexity is readily apparent at the beginning of the music. The pattern in event complexity begins at E4 at 4'30", while the uncertainty shown by Partially Indeterminate Events starts with the one off event E1 at 1'30", but from E9 at 11'30" Partially Indeterminate Events continue to occur with great frequency until the end of the music. Overlaying the grouping patterns of the two charts shows two quite

different temporal designs, although broadly as the technical complexity of the music collapses over time, the amount of documented uncertainty reflected in Partially Indeterminate Events is increasingly continuous.

d. Most Common Attribute Combinations over Time

The music as a whole is examined for the time points of the Most Common Attribute Combinations, looking for obvious replications of sound events with identical attribute combinations across the time domain. This analytical chart includes all attributes, cognitive as well as the technical attributes. This is different than the previous analysis of the contour of technical complexity, because it places cognitive events on an equal footing with any technical attribute(s). For some listeners, cognitive events may be their primary way of responding while listening to the music. In these instances, this analytical chart allows that information to rise to the surface. Overall, this analytical chart provides information on whether and when specific sound events with identical components are repeated. This information can imply repetition or variation as the music unfolds which gives another insight into possible formal structures such as Rondo, where the opening theme is repeated several times after interjected alternate sections.

Overall, there is no simple and direct regularity about the times at which these most frequent Attribute Combinations occur. Yet, visually there seems to be some kind of interactive relationship in the time patterning of these events. For instance, the series of events containing Reflective Event and Silence and Partially Indeterminate Event starts 10 minutes later than, but echoes the pattern established by the series of Partially Indeterminate and Event Duration and Texture and Sound Source. Then another series, Reflective Events and Sound Source, show this pattern in reverse, ending 10 minutes before the conclusion of the music. Hence, this reversal appears as a sort of mirroring of the latter two series around the mirror point, E14 at 15'20", which contains Event Duration and Texture and Sound Source.

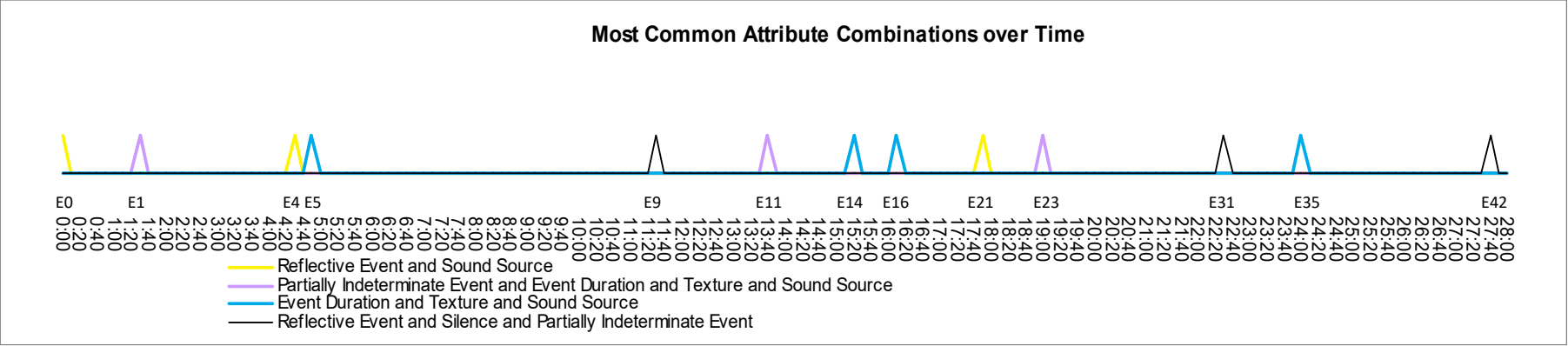


Figure D.19. *Concert for Piano and Orchestra*: Most Common Attribute Combinations across Time

e. Repeated Transition Pairs at Attribute level

Figure D.20 below is empty because, as observed previously, all Transition Pairs are unique, as they only occur once, so no single Transition Pair can be identified as the most frequent. Hence, there is no visual representation of this aspect of the listening experience, as the chart would not contain any useful information. However, there is one attribute-identical Transition Pair in the entire piece of music. E27-E28 at 20'40"-20'50" are sound events that are identical at the attribute level. All other Transition Pairs have varied Attribute Combinations in each adjacent event, which highlights the degree of continual variety within this music.

Partially Indeterminate Events are documented for one or both sound events in 27 (64%) Transition Pairs, while 37 (88%) Transition Pairs include Reflective Events.

There are no repeated Transition Pairs in this experience of this music.

Figure D.20. *Concert for Piano and Orchestra*: Repeated Transition Pairs across Time

f. Time Structure of Feature Sets

Six Reflective Events occur in the first half of the music, with 18 occurring in the second half. The six Reflective Events associated with Partially Indeterminate Events visually mirror around E15 at 15'50", while also included in the three Multi-featured events towards the end of the music, such as E38 at 25'30". Recall of Similar Material events, unsurprisingly, occur towards the end of the music, with the exception of E4 at 4'30". There is little in the music to directly focus attention on particular sound events, but the temporal placement of these Attentional Focus events, E0 at 0'00", E8 at 8'40", and E21 at 17'50", cut the music into three (fuzzily) equal time periods. There are additional Attentional events at the end of the music, such as E40 at 27'10" a Multi-featured Reflective Event, and E41 at 27'30".

Figure D.2. *Concert for Piano and Orchestra*: Feature Sets of Reflective Events over Time above shows that of the 24 Reflective Events, six are Multi-featured. The only Multi-featured Reflective Event, E40 at 27'10", is the documented moment when I lost interest in the music because it appeared aimless and illogical. The other five Multi-featured Reflective Events are associated with long Silences. These are the

four events E31 at 22'30" to E38 at 25'20", along with last Reflective Event documented for this music, E42 at 27'40", the final Silence event of this music.

Figure D.3. *Concert for Piano and Orchestra*: Feature Sets of Partially Indeterminate Events over Time above shows that Partially Indeterminate Events primarily occur in the final two-thirds of the music. The temporal distribution of Features in this attribute are book-ended by two of the twelve Emergent Feature events, E1 at 1'30" and E42 at 27'40", although these events do not occur at equal time intervals from the respective end points of the music. There are another six Emergent Feature events, starting with E9 at 11'30" and concluding with E33 at 23'10", which form a fuzzy mirror around E19 at 17'10" and E20 at 17'30", which are Uncertain Sound Source events. Outside this mirroring, towards the end of the music, there are another four Emergent Feature events.

The sound events documented in other feature sets in Partially Indeterminate Events fall within the third quarter of the music. The first Notable Single Feature occurs very near the midpoint: E11 at 13'40", while the other two, E27 and E28 at 20'40" and 20'50" respectively, occur very near the three-quarter mark. These three events show a pattern of mirroring around the time points E19 at 17'10" and E20 at 17'30", very similar to the mirror pattern of Emergent Feature events. In fact, the Uncertain Sound Source events, themselves, also show this mirror pattern. The first Uncertain Sound Source event, E12 at 14'20" and the final event is E25 at 19'40", are both 2'40" from the centre points E19 at 17'10" and E20 at 17'30".

Figure D.4. *Concert for Piano and Orchestra*: Feature Sets of Amplitude over Time above shows that Amplitude is an infrequent descriptor of sound events in this music. Only five sound events include Amplitude, distributed over four fuzzy feature sets. However, even within this minimal existence there are still patterns to be discerned. The two sound events which Die Away occur at significant time points: E10 at 12'40" occurs just before the central time point: 13'40; and E41 at 27'30" occurs immediately just before the end of the music: 27'40". Apart from E41 at 27'30" the other events in Amplitude bounded by E8 at 8'40" and E39 at 25'30", continue the off-centre mirroring shown by the Features in Partially Indeterminate Events around the time points 17'10" and 17'30", even though in Amplitude there is no documented event occurring at this time point.

Figure D.5. *Concert for Piano and Orchestra*: Feature Sets of Register over Time above also shows that Register is not frequent in this music, as it contains only six events. Two Bass events, E6 at 5'50" and E26 at 20'10", occur at fuzzily equal time intervals from either end of the music, while most of the documented Registral activity occurs in the second half of the music. There are two events, E22 at 18'40" and E32 at 22'50", which contain multiple Registers through repeated Glissandi. Although Glissandi occurred in other events, they did not repeatedly cycle through the Registers in this manner.

Figure D.6. *Concert for Piano and Orchestra*: Feature Sets of Event Duration over Time above shows the temporal pattern of the 20 sound events described by Event Duration. It is noticeable that some Features are repeated closely in time, such as E6 at 5'50 and E7 at 6'20", adjacent events in this attribute which are both Quick. There are also three pairs of Sustained, and one pair of Regular Duration events. Most Sustained events occur in the second half of the music. Indeed, the second half of the music is almost the inverse of the first half. There is a large period of inactivity in the first half between E7 at 6'20" and E10 at 12'40", ending 1'00" before the central time point of 13'40". In the second half of the music, the equivalent time interval of 6'20", beginning 1'00" after the central time point, is actually the period of the most intense activity in this attribute. Two Multi-featured events occur at the middle and end of the music: E11 at the central time point: 13'40; and E40 at 27'10" are the ends of a fuzzily equal time interval of 13'30".

Figure D.7. *Concert for Piano and Orchestra*: Feature Sets of Texture over Time above shows that both Polyphonic Events occur in the final quarter of the music, while most of the Single Sound events occur in the third quarter, although both the first and final sound events in this attribute, E1 at 1'30" and E41 at 27'30", are Single Sounds. The six Monophonic events do not occur at regular intervals although the visual mirroring of the two outer pairs of Monophonic events at each end of the music is apparent. The one purely Homophonic event E11 occurs at the central time point of the music at 13'40".

Figure D.8. *Concert for Piano and Orchestra*: Feature Sets of Sound Production Method across Time above shows that a large majority of the fourteen sound events in Sound Production Method occur in the second half of the music. The Tremolos

occur in the first third, while the Unknown Sounds occur in the third quarter, and the Glissandi occur in the final third of the music.

Figure D.9. *Concert for Piano and Orchestra*: Feature Sets of Sound Source across Time above shows that the individual instruments each appear more frequently in different segments of the music. Strings occur six times starting at E6 at 5'50" to E37 at 25'00", the Clarinet only appears in the third quarter of the music, while Piano primarily appears in the final third of the work, from E26 at 20'10" to E41 at 27'30". Flute appears only once at E21 at 17'50", clearly in the middle third of the music. The only times when the whole ensemble sounds together simultaneously are Piano with Orchestra as a whole at E0 at 0'00", and Orchestra Alone at E4 at 4'30", Although, E11 at 13'40", at the central time point of the music, is similar in that several, but not all, instruments sound simultaneously.

Stage 9. An Abductive Interpretation: The Idea that Makes Sense of this Experience

This stage draws out the overall key idea suggested by this experience of the music, and what this experience suggests about the compositional design. These abductive conclusions follow through on earlier hypotheses formulated immediately before listening presented in Stage 1, and immediately after listening presented in Stage 3, as well as the implications of the analyses presented in Stages 7 and 8. In Stage 9, this synthesis links the technical features observed during listening and the previous hypotheses, to draw conclusions about the idea that makes sense of this experience.

a. Implications of Frequency of Technical Attributes, Attribute Combinations, and Feature Sets

In this music the maximum possible technical attributes for one event is six. Only two events in this music contain five attributes. There are five events which include four attributes apart from Reflective Events. Thus about one-sixth of all events can be considered complex. Sound Production Method, Sound Source and Texture along with variations in the other attributes are noticeably exploited in this music or this degree of complexity would not be documented for so many sound events.

Figures D2-D9 in Stage 2 above shows that in this music very few sound events are Multi-featured. Register and Event Duration both contains two inclusive events, while Sound Source contains only one. This means that most technical events in this music are not inherently complex in terms of classification into particular fuzzy feature sets within an attribute. The actual Features of each sound are relatively simple and transparent, yet a large number of descriptors are required to capture the range of variations. Across all the attributes, three feature sets contain around 15% of total events each, while there are 14 Features which each describe four or five events, each around 10% of total sound events. There are 18 feature sets which contain up to three events, each around 5% of total events.

In the case of *Concert for Piano and Orchestra*, the six Features in the attribute of Sound Production Method immediately sets this music apart. Conventional musicological analysis is principally concerned with the organisation and development of pitch-based materials, seen as the standard means of designing music to express an idea. Sound Production Method would be given a little importance, typically only a passing glance. This reflects conventional music design in which changes in Sound Production Method are most often used to underline changes in thematic materials or harmony, rather than as an attribute in its own right. Yet *Fuzzy IDEAS* shows that, by examining the sound of the music as comprehensively as possible with a set of human ears, and ensuing visual analysis, Sound Production Method is a very important component of the design of *Concert for Piano and Orchestra*.

Sound Production Method is documented for 44% of events, while Sound Source is documented for nearly every sound event in the music, 79% of all events, of which 93% of Sound Source events are documented as containing only a single Sound Source. Yet the Orchestra as a distinct entity is rather absent. The Orchestra, both with and without Piano, occurs only three times out of the 43 documented events. By comparison there are six Silence Events. Texture is included in 55% of total events, of which 87% of Texture events contain only one 'voice'. Event Duration is included in 51% of total events, of which 86% of these events are of Long or Sustained Duration. Amplitude is not a primary aspect of this work as it is infrequently observed, primarily at times when various other Features emerge or disappear in the overall sound of the music. Register is also relatively infrequent. In

summary, around 90% of events contain an unaccompanied single Sound Source in Long Duration events, implemented by a wide variety of Sound Production Methods.

Together these statistics suggest that each sound event is both simple in sound and complex in terms of variety of Features and attributes. This suggests that the music is concerned with the quality of sound in itself.

Partially Indeterminate Events are documented for 19 of the 43 sound events (44% of total events). Emergent Feature is the most common feature set, contained in 27% of total events. The number of events and the primary feature sets of Partially Indeterminate Events show that many sound events are not clearly defined.

Reflective Events are included in one or both sound events in 37 (88%) Transition Pairs, while 26 (62%) Transition Pairs include a Partially Indeterminate Event.

All 42 Transition Pairs occur only once in the entire music. There is only one Attribute-identical Transition. All the other Transition Pairs contained differing Attribute Combinations between initial event and its adjacent event. Silence Events were all approached differently. This clearly reinforces the idea of continual variation among events across the whole music.

In *Concert for Piano and Orchestra*, none of the events immediately preceding the six Silence events have identical Attribute Combinations. The sound event that occurs immediately before the final Silence of the whole music, is one of the most complex events in the entire music as it contains five attributes. It is certainly the most complex event that immediately precedes any of the six Silence events.

b. Implications of the Uncertainty Experienced by this Listener

Uncertainty is suggested by various aspects of the results. It is reflected by the number of Multi-featured events; the number and types of Partially Indeterminate Events; and the qualities of the Silence Events.

Multi-featured events denote the ambiguous nature of individual sound events that contain elements pertinent to several feature sets in the same attribute. Partially Indeterminate Events by definition denote events with uncertain boundaries, whether in the time domain or the technical description.

A large number of Multi-featured Reflective Event occur near the end of the music.

Nearly 1 in 2 sound events across all attributes are classified as Partially Indeterminate Events. Emergent Feature Time Point is included in 1 in 4 individual event descriptions. Emergent Feature Time Points occur at those time points when the listener becomes aware of something only because continuation had brought it to consciousness. Uncertain Sound Source accounts for nearly 10% of sound events.

All the Silence events have additional attributes. This implies that there the composer has generated a sense of uncertainty regarding the convention that significant Silences mark the end of the music. The abductive conclusion is that there is no strong narrative flow throughout the music.

c. Implications of Reflective Events

Reflective Events are documented for 24 events (55% of total events) in this music. Figure D.2 in Stage 2 above, shows that most Reflective Events occur in the third quarter of the work, with very few occurring in the first half of the music. Nine Reflective Events arose through Partial Indeterminacy of some aspects of these sound events. These sound events occurred at shorter time intervals as the music progressed, becoming quite dense for the last five minutes of the music. It was increasingly difficult towards the end of the music to understand the purpose of some individual sound events.

Although Reflective Events which document Free Range Thoughts occur in the central portion of the music, between E13 at 14'50" and E20 at 17'30", these Reflective Events are concerned with identifying Sound Source for unusual sounds. In contrast, the sound events in the last five minutes of the music stimulated very different Reflective Events through the lack of definition or apparent purpose for these particular sound events. The Reflective Events in the final five minutes of the music document *ennui* and question whether or not each particular Silence Event marks the end of the music²¹⁷.

²¹⁷ This potentially raises the bigger question of how does a listener recognise the end of the music. For now, the issue is resolved when the recording moves onto the next track, but is deserving of much more attention in future work.

d. Implications of the Time Domain: Silences as Break Points

Visual analysis of Sections determined by Silences in Figure *Concert for Piano and Orchestra*: Segmentation using Silence Events as Break Points above, shows that relationships clearly exist between a number of Sections, both directly in terms of duration and indirectly in terms of their content, as described by the 'horizon' of total attributes for each sound event at each time point. Mainly the relationship between sections is a temporal pairing between Section 1 and Section 2, respectively 11'30" and 11'00" in length, then between Sections 3,4 5 and 6, as a group, with a total duration of 3'10". The relative durations indicate that Sections 1 and 2 are both significant divisions in the music, while the remainder of the music although logically divided into sections by the Silence events, perhaps could be more usefully considered as a whole to be an ending section to the music, designed to reinforce the nature of the finale, particularly as Section 6, the very end of the music concludes in a similar way to the end of Section 2, with complex sound events which both include Amplitude, an infrequently occurring attribute. The difference is that E8 at 8'40" is Loud, and E41 at 27'30" is Dying Away.

This segmentation by Silences suggests that the music is in two halves of about 11'30" duration, followed by a type of 'coda' which gradually refines the earlier materials of the music, resulting in a series of interruptions of either the final silence, or the music, depending on one's perspective. This 'coda' in fact refines the materials of the music to the extent that the music is no longer flowing but rather dribbling off into nothingness. This contrast is evident despite the fact that the music never has flowed in conventional sense. Most of the music consists of pointillistic sound events which have qualitative relationships to each other but are not in the grouping or pattern relationships typical in conventional music, such as melody or regular rhythms.

There seem to be two things occurring in this music. One is a story of gap-filling: the time interval in one section in which nothing is noted is, in a similar time interval in the next section, filled with events. The second observable relationship is simply the duration of the sections in relation to each other, and the nature of the events within those time intervals. As the final four sections are quite short, this illustrates how

the final part of the music sounds quite disjointed, even though the visual analysis reveals that there are some analytical connections between these sections.

e. Implications of Attributes over the Time Domain

On examination of the analytical charts, it is apparent that there are several time sequences overlaying each other. The overall effect of this overlay is to completely obscure any individual pattern when listening. The patterns are only revealed by analysis of the fuzzified data about the music after mapping into visual representations of the experience of the music.

Firstly, several attributes occur differently in various time intervals in the music. Event Duration is most frequent in the second half after the central time point, E11 at 13'40", although the first quarter contains several events in this attribute. Register is also more frequent in the second half. By comparison, Partially Indeterminate Events mainly occur in the final two-thirds of the music. Texture primarily occurs in the first and third quarters.

Secondly, there is a type of mirroring which introduces variation as the mirror point changes in time for different attributes. These mirror time points are visually noticeable in a number of attributes even though on occasion the mirror point is empty, as it does not contain a sound event with the same attribute.

The analytical chart, Figure *Concert for Piano and Orchestra: Most Common Attribute Combinations across Time*, also show mirror patterns. In summary, the time distribution of various mirror points all occur in the second half of the music: E11 at 13'40", E14 at 15'20", E18 at 16'30", and the pair, E19 at 17'10" and E20 at 17'30". However, the continually different transitions between Attribute Combinations indicate very little structural relation between events.

Thirdly, there are some specific markers of individual time points. The only Attribute-identical Transition Pair in the entire piece of music, E27-E28 at 20'40" - 20'50", occurs at the fuzzy three-quarter time point. The sound event E11, which occurs at the central time point of 13'40", repeatedly arose to prominence in the detailed analysis of the fuzzy feature sets over Time.

The analysis reveals that there seem to be two processes, neither of which is available to conscious perception while listening. The two processes together mean that the music is in a state of continual variation. In summary, the results of all these different processes - mirroring, sectional prominence, and gap-filling - is that there is no direct relation between parts of the music, or sequential development of attributes over time. The temporal design based on the analytical charts is quite abstract. This in itself indicates that the work is very much about continual variation of the sounds themselves, rather than variation through harmonic or motivic development. This suggests that the idea behind the music is to provide an immersion in the sonic possibilities of the instruments, rather than using the instruments as a whole to express an emotion or tell some other story.

Figure D.19. *Concert for Piano and Orchestra*: Most Common Attribute Combinations across Time above shows the most frequently occurring Attribute Combinations across the time frame of the whole work. Grouping these events together gives insight into how particular event types outline a temporal structure, which suggests one aspect of the compositional design of the music. Overall, there is no simple and direct regularity about the times at which these most frequent Attribute Combinations occur. Yet, visually there seems to be some kind of interactive relationship in the time patterning of these events. For instance, the series of events containing Reflective Event and Silence and Partially Indeterminate Event starts 10 minutes later than, but echoes the pattern established by the series of Partially Indeterminate and Event Duration and Texture and Sound Source. Then another series, Reflective Events and Sound Source, show this pattern in reverse, ending 10 minutes before the conclusion of the music. Hence, this reversal appears as a sort of mirroring of the latter two series around the mirror point, E14 at 15'20", which contains Event Duration and Texture and Sound Source.

f. Implications of the Time Domain at the Feature Set Level

The analytical charts hint that there is some type of regularised organisation of features over the time domain, because pairs of events and various Features frequently seem to occur at very similar time intervals. However, these patterns are not clear cut, nor directly related to the opening or closing time points, nor directly

repeated even within the Features of one attribute, but are similar among a few Features across attributes.

Firstly, there is a type of mirroring which introduces variation as the mirror point changes in time for different Features. These mirror time points are visually noticeable in a number of attributes even though on occasion the mirror point is empty, as it does not contain a sound event with the same attribute. On other occasions, the mirror point contains a different Feature in the same attribute. The second process suggested by the analytical charts is that of segmentation occurring at different time points in different dimensions of the music. Firstly, each attribute has different dispositions of its constituent fuzzy feature sets over time, so that particular Features are highlighted in different parts of the music. Most Features dominate in only one segment of the music. However, the segmentation is different for each attribute. For instance, Strings do not appear in the first quarter of the music, Clarinet only appears in the third quarter of the music, while Piano primarily appears in the final third of the work. The third quarter of the work is also the only place where Uncertain Sound Source occurs. This temporal patterning of sound types overlays the time patterns of the other attributes.

Secondly, all Features in Partially Indeterminate Events, from E9 at 11'30" concluding with E33 at 23'10", show a mirror pattern around E19 at 17'10" and E20 at 17'30", both of which are Uncertain Sound Source events. Outside of this mirroring, there are an additional four Emergent Feature events towards the end of the music. The events in Amplitude have varied Features and are more widely dispersed, from E8 at 8'40" to E39 at 25'30", but together have the same mirror point, E19 at 17'10" and E20 at 17'30", with an additional event at the end of the music. Other Features which include mirroring are the Bass notes in the attribute of Register, E6 at 5'50" and E26 at 20'10", are fuzzily six minutes from each end of the music, while Monophonic in Texture also mirrors around the central time point, E11 at 13'40". Homophonic Texture follows this pattern in the most minimal way, as the only Homophonic event occurs right at the central time point, E11 at 13'40".

In summary, the first process simply breaks the music into discrete segments, sometimes halves or quarters, sometimes thirds. This is not a mirroring process but still indicates a design based around equality of time intervals. The second process

is a mirror process. Together the accumulation of these details mean that different attributes and Features show different patterns over time. These temporal patterns show there is little repetition, hence much variation in the sounds of this music.

The Abductive Idea that Makes Sense of this Music

All the previous contemplations and analytical implications combine to suggest an idea as the foundation on which this music was composed. I am not arguing that this idea is the correct interpretation, or that every listener will or should make sense of this music in this way, or that the composer intended to communicate this specific idea. Rather, this idea is one possible way to make sense of this music.

Potential Idea 1: Implications of the Title

The title suggested that there would be a large ensemble of instruments playing together to achieve a unified goal, and as an accompaniment to the solo Piano.

Potential Idea 2: Immediate Impressions

I finished listening with the impression that this piece was an exploration of sound itself, designed to highlight the variety of timbral possibilities inherent in instruments, to provide a sonic experience of timbral colour, and enable reflection by the listener on the inherent qualities of sound itself. This was suggested by the simplicity of the Texture, with many Single Sound events, together with the Long and Sustained Event Durations. These attributes and Features focus the listener on the quality of one sound, and then another. There was lots of variation with most events being different in some way, yet there was also lots of similarity in various playing techniques such as Glissando and Pizzicato events, which, despite different Sound Sources, produce quite similar aural effects.

Potential Idea 3: Logical Conclusions from Visual Analysis

Unusual occurrences include those sounds impossible to associate with a conventional acoustic instrument. A small number of sound events did not have a clearly identifiable instrumental source, which presumably results from an unusual, and hence unidentifiable, playing technique. For example, E12 at 14'20" is a series

of continuous shrieks. I had to remind myself that this work did not contain any electronics or sampled sounds. Additionally, a whole range of sounds passed into my ears that did not conform to any conventional ideas about music, such as E14 at 15'20"-E15 at 15'50", which starts as a String sound and concludes as a Clarinet.

An Abductive Interpretation: The Idea that Makes Sense of this Music

Calling the ensemble 'Orchestra' is quite a stretch of the normal sense of the word, as the actual sound of the 'Orchestra' was more like the sound produced by a small collection of individual instruments found in a chamber ensemble. The term 'orchestra' has more resonance with the idea of playing together as one, whereas a chamber ensemble is more a collection of individuals engaged in dialogue. Primarily the sound events consisted of Single notes, while there was a distinct absence of long Piano solos. The so called 'Orchestra' only played as a complete group at E0 at 0'00" along with the Piano, although there is a nod towards the 'Orchestra' in E4 at 4'30" and at E11 at 13'40", the central time point of the music, when a number of instruments play simultaneously. These occurrences in the music suggest that the title is not a literal signpost to the aural character of the music.

In retrospect, after analysing the listening observations, it is possible that the missing 'o' and the uncertainty surrounding the resulting word might be a signpost to the larger idea that the composer is about to play with notions of what conventionally constitutes music. The instruments do not perform in any audible relationship to each other except in terms of Sound Production Method. There is no aurally apparent larger grouping of materials into sections or noticeable continuity to form groups of sound events between Piano and 'Orchestra'.

Concert for Piano and Orchestra provides an environment in which the listener is encouraged to contemplate the nature of the sounds themselves, and through this to challenge the conventional concepts of 'music' itself. The analytical charts suggest that the idea behind this music is that individual sounds are both the means of creating the music and the end goal of the experience of the music. This compares with other music where the individual sounds are relatively unimportant, but together form an identifiable melody or other grouping that demonstrate some kind of goal oriented progression. Conventionally, these groupings provide the structural materials to express a more abstract idea, story or technical exploration of

materials, through the medium of music, including abstract ideas about sound in relation to music. Initially, *Concert for Piano and Orchestra* seems only to be concerned with the idea of continual variation of sound itself, rather than using the sounds collectively in thematic materials or motivic development or to outline harmonic regions. The listening observations indicate quite clearly that timbre is overtly important in this work. The emphasis on the timbral qualities of sound is reinforced by the similarities in Sound Production Method across a number of instruments as the music unfolds. In listening to the music, it is obvious that the composer is seeking equivalencies between instruments, such as *staccato* in flute and *pizzicato* in violin.

This series of sounds collectively known as *Concert for Piano and Orchestra* has been organised to challenge the conventions of ‘music’, rather than simply providing a space to contemplate the inherent beauty of individual sounds. The first indication is that sound quality is important but only part of the bigger idea of this music because there are a number of Unidentifiable Sound Sources which occur only once and generally would not occur in a conventional piano concerto. As well as several Unidentifiable Sounds, there are several unusual sounds, such as the String Scrape and Unidentifiable Sound Source for the ‘yip’ that are not heard in conventional music, and several references to sound worlds external to this work, such as baby cries, sirens, and jazz.

Secondly, the shaping of this music into a temporal design is quite unconventional. All Transition Pairs are unique: there are no repeated transitions at any time point in the music. There are no repeated or self-referential parts of the music apart from the Silence events which occur in the last five minutes of the music. There is no melodic content, including phrasing, or harmonic movement anywhere within the work. The only apparent shaping forces are the slow beginning with a Single Sustained sound, and the increasing number of Silences towards the end which ensure that the individual sounds become pointillist, increasingly discrete and separated; until the occurrence of a sound event, Piano which Dies Away, that eventually concludes the music. Texture is simple, as most are Single Sound events of Long Duration.

The major source of differences between sound events is through change in Sound Source or change in Sound Production Method. Significantly, the amount of change between events was most often constrained to one of these two dimensions.

Together this emphasises the sonic nature and variability of the individual sound events, rather than a flow of events as a whole. Conventional music is more often discussed in terms of coherence and flow, the balance between variety and repetition, the audible continuity between sound events, as seen in the types of relationships I have been seeking in visual analysis of the listening observations.

It is clear that the central time point is significant in the composition of this music as it recurs in so many different ways during analysis of the analytical charts, and was obviously a significant event at the time of listening, or else it would not have been documented. Yet, by the end of the music this single event is easily overtaken by events later in the music not audibly related to E11 at the central time point, but rather with characteristics all their own. This suggests that each sound event is designed as pointillist, to be individual in its own way.

Relationships between the sections of the work do not show any direct repetitions, as would occur for example, in sonata form where themes would be repeated in different sections of the music. The temporal structure of Cage's music suggests that he is concerned with ensuring that every possible timbre for sound events occurs at least once in the music. This is reinforced by the frequency distributions of attributes, which shows that the basic attributes of Amplitude and Register are infrequent in this music. However, the additional attributes, which are useful to describe the individual nature of the sounds of this music, all relate to the timbral qualities of sound. Even Event Duration is described primarily through the Sustained and Long feature sets. This only enhances attention on the quality of the sounds as they occur, not only through such sustained focus on one sound, but also because there is no apparent temporal linking between sound events through a discernible tempo or rhythm. The great variety in fuzzy feature sets required to describe this music also shows the range of variation between sound events. All this leaves an overall impression that this music is designed as a sonic experience, to value the qualities of individual sounds, rather than a goal-directed progression of events performing a narrative function to express a larger idea. Immediately after

listening, the composer seems concerned with highlighting, comparing, and contrasting the timbral possibilities inherent in the individual instruments.

Yet using all the tools provided by *Fuzzy IDEAS*: consideration of the Title, the immediate effect of listening to the music, the way the music sets up the possibility for, in fact nearly the necessity of, Reflective Events, and all the technical evidence just presented, it seems that the music could be consciously designed around another overarching idea. The meta idea suggested by *Fuzzy IDEAS* is that the music is designed to provide an environment for reflective introspection on music conventions: to challenge the conventional relationships between materials and structures usually associated with music, and to explore the relationship between sound and music, especially given that music requires sound as a basic prerequisite for existence. Certainly the music provides an environment for Reflective Events. Evidence is provided by the 55% of listening observations, and 88% of Transition Pairs which include a Reflective Event, which shows that this music is able to stimulate a significant amount of extra-musical cognition.

Further evidence for the meta idea that *Concert for Piano and Orchestra* is designed to use the materials of music to challenge conventional concepts of music arises from two places. Firstly, as discussed previously, the naming of the work 'Concert' held a number of possibilities and uncertainties. Interestingly, the Piano only plays once simultaneously with any other instruments in E0 at 0'00", the very first sound event of the music. Additionally, the small collection of instruments which constitute the 'orchestra' only plays twice as a synchronous co-ordinated ensemble: E4 at 4'30" and E11 at 13'40". Rather, the instrument collection is used as a set of individuals where each performs with their own range of possibilities. Finally, the naming of what is effectively a chamber ensemble as 'orchestra' challenges conventional definitions.

The aural experience could be interpreted as individuals working separately towards a common goal of communicating the qualities of sound. The concept of working together as a team could be evidenced by the playing techniques in common between the Piano and the 'Orchestra'. Similarly, although Piano is the most frequent individual Sound Source, its 11 occurrences do not dominate the music, as there are 33 other events which are not Piano events. What occurs during

listening is a focus on each individual sound event in its own right, not as an element that can be aurally related to a larger overall temporal design. Again this challenges conventional concepts of music, where individual sounds are designed together based on harmony, rhythm and melody, to produce a whole formal design.

The challenge to 'music' is set down by the title, and this challenge is taken up by the sequence of sounds that bear little audible relation to each other in a conventional way. This music is not a set of sounds unmistakably flowing towards a final conclusion, which clearly ends rather than just dribbles away. *Concert for Piano and Orchestra* does not have a clearly delineated conclusion. The listener is left wondering for five minutes as the Silence events continue to accumulate, interspersed with apparently random individual sounds which continued in an odd desultory way, whether or not this event is the final one. In a sense, this imitates on the larger scale all the indeterminate sounds with unclear boundaries and uncertain Sound Sources. In fact, the amount of indeterminacy increases in the second half of the music, rather than drawing the previous materials together. The Multi-featured Reflective Events, which predominantly occur during the final few minutes, indicate how much these Silence events affect the conscious cognition of this music. The effect of the continued repetition of Silence Events towards the end of the music is to generate a degree of *ennui* with the music as frustration builds with the continual repetition of Silence followed by Single Sound events and the lack of clarity about an end point. The repetition of events during the 'coda' at the end of the music gives significance to the last events to occur and remain with the listener. In summary, all these factors add up to music in which normative thinking about music is quite out of place. This suggests that the meta-idea behind this music is to challenge the conventions of music by emphasising the possible sounds which can contribute to music, rather than using a limited palette of sounds in a progressively transforming formal design.

Appendix E. Avant-garde Music in the 21st Century Australian Marketplace

In 21st century Australia, composers are reliant on market support, rather than patronage or public funding. Audience response has always been important for the survival and development of Western art music. For the most part this occurred through patronage rather than the market place, therefore much of what is currently accepted as art music was not composed to primarily and directly attract a fee-paying audience.

Prior to the 19th century, what is now considered ‘art’ music was either church music, or music to entertain aristocrats. In both cases, composed by their employees, who were given ongoing regular financial support in kind, such as food and board, or annual stipends in return for their compositional work. However, this changed during the 19th century. For example, as documented by Kerman, Tyson et al., Beethoven working around the end of the 18th century was initially supported by the Elector of Bonn then, in later years, by Viennese aristocrats both as patrons and as keyboard students. Nonetheless, Beethoven gave his first concert to support himself in 1802. Although working independently, he continued to dedicate his work to various noblemen of the city in exchange for patronage and commissions until his death in 1830 (Kerman, Tyson et al.). Similarly, as documented by Millington, Deathridge et al., Wagner initially supported himself as a journalist, chorus master and conductor, however, after his appointment to the Dresden court in 1843, he was supported financially by wealthy patrons for the rest of his career (Millington, Deathridge et al.). By contrast, as documented by Franklin, Mahler, a late 19th century composer, worked throughout his composition career conducting opera on contract to both state and court owned theatres (Franklin). These biographical details support McClary’s assessment that by the end of the 19th century, the rise of capitalism had brought composition and performance into the market place, whereby art music has become pure entertainment (McClary, 2000:114). This trend continued throughout the 20th century so that mainstream music production in the 21st century is driven by market forces, dominated by financial rather than cultural or prestige concerns. Babbitt’s 20th century economic evaluation that new art music has “...little, none, or negative commodity value”

(Babbitt, 1958), appears to still hold true for the 21st century, since avant-garde music infrequently appears on concert programs directed towards mainstream audiences.

There is a small but relatively lively 'new' music scene in Australia. In March 2014, the Australian Music Centre online calendar contained 85 concerts by Australian musicians (Australian Music Centre). This figure includes those 14 concerts mentioned previously which feature Australian compositions by flagship companies. A very small proportion of the concerts contain jazz, film, rock or folk-oriented music. Every one of these 85 concerts contains at least one piece of contemporary art music; many contain four or five pieces of 20th century music. While this may look to be a thriving industry, the actual audience sizes are small. The vast majority of concerts are produced and performed by chamber music ensembles on tour in small venues, anywhere in Australia. Similarly, but with a focus on premier performances of newly composed work, the New Music Network online calendar for 2014 documents between one and six concerts each month between March and November, 25 concerts total, each concert being a one off,¹ rarely held in large concert halls (New Music Network). There is no doubt that contemporary art music continues to occur in niche concerts, however, direct funding to this premier organisation for performances of new music has been reduced significantly in 2014 for future years ("Can you help?" New Music Network). Most 21st century art music composers must work in other related occupations, such as conducting, performing or teaching, rarely being able to support themselves directly from their compositional investigations.

Employment opportunities for composers in the Australian music industry are declining. The Australian Bureau of Statistics reports that the total number of paid staff in all genres from rock to chamber music, including performers and production staff in live performance venues, as well as composers, has fallen by 20% between 2001 and 2006 (Australian Bureau of Statistics, 2010). The Australian Bureau of Statistics also reports that the number of people attending live classical music concerts in any year, has remained fairly constant at around 9% of the adult

¹ New, unconventional music is usually given a premier performance, but rarely programmed for repeat performances unless the music receives a strongly positive audience response.

population for the last 15 years (Australian Bureau of Statistics, 1995; 2011). The total number of audience members has increased due to population growth, which provides some possibility of increased audiences for avant-garde music, perhaps in niche concerts, if composers can survive to write the music in the first place. However, concert programs for the flagship ensembles, which have the largest audiences, seem to include the same old styles of music. This programming presumably reflects the existing tastes of the majority of concert goers, as the ensembles strive to balance budgets.

A quick survey of concert programs for March 2014 by four major Australian companies with large audiences² show that 121 pieces of music are documented, including the repeat performances of the same music in different venues. In that month, a total of 19 pieces were composed by Beethoven alone. Beethoven enjoys the same popularity as the 18 performances of music which audiences may consider unfamiliar. Arguably, from a 21st century perspective, the vast majority of this music is not avant-garde music pushing at the boundaries of conventions in music composition³. Although 55% of all the performed music, including the music enumerated previously, was composed throughout the 20th century, the majority of that music could not be considered to be extending music techniques into new domains, although it might be extending the range of music experienced by the audience. 17 pieces were composed by Russian composers, 5 are screen music concerts, 5 are jazz influenced performances, one single 'world music' concert, while the majority of the 22 performances of music composed in the early 20th century is music in the Romantic style of the late 19th century.

In 2001 the Australia Council provided \$3,753,000 for 206 individual music projects (Australia Council, 2001:75) compared with \$4,437,000 for 240 music projects in 2013 (Australia Council, 2013:21). These amounts include funding for performance

² Four flagship ensembles considered for this quick survey were selected for their popularity, and hence their large audience reach: the Melbourne Symphony Orchestra, the Sydney Symphony Orchestra, Musica Viva Australia, and the Australian Chamber Orchestra. The Australian Chamber Orchestra did not perform in Australia in March 2014, so in effect, their programming has not been included in this survey.

³ The count includes one performance each of music by Webern, Glass, Nielsen, Sculthorpe, Kapustin; three performances of music by Edwards, and 10 by Vine. Music by Australian composers: Edwards, Vine, and Sculthorpe is, perhaps arguably, not avant-garde music. Avant-garde music investigates very different territory.

development, as well as directly to composers, but do not include funding to major performance organisations like symphony orchestras or opera companies. Even though the actual dollar amount has kept pace with population growth in that period⁴, the actual value of the dollar amount has declined through inflation which, according to the Australian Bureau of Statistics, averages around 2.5% per year (Australian Bureau of Statistics, 2013). Thus the value of each grant to each musician is at least 25% less than it was 12 years ago. If the amount of public funds being devoted to the development of music by individual composers and performers is any measure, then public support for new music outside of the universities appears to be declining.

However, support for music within universities is decreasing, as evidenced by the Music Council of Australia which identified a 50% decline in funding provided for teaching hours in Australian tertiary music schools over the last 20 years (Global Access Partners, 2011:10). However, broader audiences, including decision-makers on the provision of public funding for both universities and concerts, appear not to value music as an artform in continual development.

The impact and implications of the thought revolution of the 20th century remains full of possibilities still being explored by composers in 21st century Australia. However, there is little desire for the experience of new music; hence, there is little financial support for the composition of 'new' music, within or outside the academy. In the 21st century, art music is in the market place competing with other forms of entertainment and the market does not support avant-garde music, or its composers. Little seems to have changed in the 50 years since Babbitt remarked that "At best, the music would appear to be for, and by specialists" (Babbitt, 1958). Audience sizes for all Western art music barely keep pace with population growth, while concert audiences are clearly not embracing avant-garde music.

Although we no longer speak of the 1917 Russian Revolution as a living influence on contemporary life, 21st century music audiences remain stubbornly fixed in the past. Lott's research shows Rubenstein's solo piano concert tour of USA in the 1870s is considered highly influential in changing the content of art music concerts in the

⁴ The national population grew by 1.8% in 2012-2013 alone (Australian Bureau of Statistics, 2013).

USA (Lott, 2003:291). At the time, the usual repertoire for a concert tour was the performer's own music. Rubenstein has been credited with initiating performances of a canon of masterworks to the concert circuit (Lott, 2003:293). However, Lott argues that although Rubenstein was clearly influential in instituting public performances featuring 'masterworks' from an established canon, he was continuing a trend started by American solo pianists, and even more so by well-regarded European female soloists touring the USA in the decade preceding Rubenstein. However, unlike Rubenstein, these other performers always included contemporary compositions in their concert programs (Lott, 2003:293-294), whereas Rubenstein's concerts primarily featured the music of dead composers (Lott, 2003:294).

Lott points out that until the mid-19th century, it was not considered appropriate for women to be professional concert performers, but in the 1860s, women had begun to undertake professional tours. However, it was still not acceptable for women to be composers, so these concert artists had to perform the music of other composers to maintain their respectability. Hence, music of dead composers was already becoming part of the concert repertoire. Rubenstein's repertoire was not popular with critics of the time, both because the music was 'antiquated' and because such serious music was not accessible to general audiences (Lott, 2003:294). However, as demonstrated by my quick survey, performance of the canon of 'masterworks' has now become the norm in Australian mainstream concerts with large audiences.

Avant-garde music is generally perceived as disruptive but in fact, most contemporary art music is not disruptive of past compositional practice, while much music now considered part of the canonic repertoire was received as disruptive in its own time. For instance, Chechlinka's archival research demonstrates how much audience attitudes to new music has changed. During the 19th century, Chopin's early music was regarded positively in Poland because it clearly reflected contemporary norms of structure and harmony (Chechlinka, 2011:214). Outside of Poland, Chopin's early music was greeted with mixed reviews, as some critics thought the music was rather unpleasant, occasionally considered to be beneath criticism because of the many chromatic notes and strange modulations (Chechlinka, 2011:215). His later music, particularly his piano sonatas, were dismissed not only in Poland but also throughout Europe. Apparently, they exhibited a lack of creative ability, because they contained too many ideas and "...did

not adhere to the obligatory rules of the genre” (Chechlinska, 2011:215). Even though Chopin’s music was critiqued in his own time, because the sounds were unconventional and unexpected, yet now Chopin’s music is now taken for granted as part of the standard piano repertoire by 21st century listeners.

Similarly, at first performance in 1804, contemporary critics found Beethoven’s *Symphony no 3 in Eb Major, op 55*, ‘difficult’. Indeed, as Sipe describes, contemporary critics wrote that the music was neither beautiful nor truly sublime. It had too many strange harmonic modulations and violent interruptions to the flow of the music, clearly indicating the composer was striving for uniqueness. The music was said to combine too many different elements in wild and fantastic ways, while being far too long. Even more, the music did not display any sign of genius to excuse its difficulties, and thus had absolutely no value. Educated listeners were bored, while for ordinary people it was regarded as “unendurable” (Sipe, 1998:54-55). However, Sipe points out that Beethoven was already regarded as a genius composer, so critics were determined to find a way to make sense of his latest offering⁵. After only a few years, rather than hearing the music as an unusual combination of technicalities that broke the rules, and consequently did not make sense, critics began to view the music as an epic story of heroic struggle (Sipe, 1998:57-58). The broader audience changed its mind once this new heroic narrative entered the public domain (Sipe, 1998:99). The symphony was then performed many times around Europe in the early 19th century to great acclaim, as it is to this day. This shows that although new music may be difficult to appreciate at first listen this does not mean that it can never make sense.

21st century listeners have been persuaded to adopt a view of 20th century music as a disruption and discontinuity from preceding tradition. Wilson, in *Groves Music Online*, points out that this story emphasises the negative impact of avant-garde music on the listening public, and blames the composers for the impact of their music and the decline in audiences (Wilson). Wilson observes that, even though leading avant-garde composers used different techniques, actually most music composed in the 20th century recognisably includes some principles of tonality

⁵ How fortunate to have such a reputation! Very few, if any, 21st century composers would have the cultural stature to influence critical reception of their music.

(Wilson). Wilson goes on to argue that, although audiences may complain about avant-garde techniques, the marketing strategies of recording companies, ensures that they are also dismissive of new music which is more 'accessible' (Wilson). 21st century listeners may not listen to avant-garde music because they now have an unprecedented choice.

Listeners in the 21st century do not have to engage with new music, or any music regarded as 'difficult'. This is different from former times when 'new music' was the only music available, 'difficult' as that music may have been for contemporary listeners. As Wilson observes recordings and radio have impacted on contemporary listening choices as music of all times and geographic region is relatively easily available (Wilson). The mass-media of the 20th century overtook public performances and domestic music-making as the primary sources of music. Wilson points out that the recording industry does not meet new demand with new music, but rather new interpretations of old music. He suggests that the problem resides not with new music but with the marketing of 'classical music' around values of familiarity, permanence and longevity, which means that new music of any genre will be struggling to gain acceptance (Wilson). The ongoing development of capitalist techniques to commodify and profit from music in the market place means that avant-garde music remains unheard by mainstream audiences. In 21st century Australia, composers are reliant on market support, rather than patronage or public funding, so the lack of general interest in, and financial support for, 'new' music is an unprecedented problem for Australian composers working in the 21st century market-driven economy.

Appendix F. Overview of Fuzzy Logic Theory and its Commercial Applications

This appendix provides information on various aspects of fuzzy logic. This appendix has four parts. It begins with the origins and historical development of fuzzy logic. Secondly, an explanation of the term ‘fuzzy logic’, which simultaneously alludes to fuzzy set theory, and logical reasoning. Thirdly, how the mechanics of Fuzzy set theory distinguish it from Classical set theory, and also from Probability theory. Finally, the appendix notes the range of practical applications of fuzzy logic in ‘smart’ automated systems for both industrial and consumer use.

F.1 Origins and History of Fuzzy Logic

Fuzzy logic was conceived to enable robots, i.e. machines controlled by computers, to emulate human thinking about complex tasks and solve multifaceted problems. It is widely acknowledged in the fuzzy logic literature¹, that Zadeh was the first person to use this term in 1965, when he first published the concepts of fuzzy logic in “Fuzzy Sets” (Zadeh, 1965), later elaborated in more detail in “Outline of a New Approach to the Analysis of Complex Systems and Decision Processes” (Zadeh, 1973). Although it seemed that fuzzy logic was independently invented by Zadeh, it is still grounded in principles of classical logic expressed in mathematical formalism. As Cordon, Herrera et al., observe “Fuzzy logic may be viewed as an extension of classical logical systems...for dealing with the problem of knowledge representation in an environment of uncertainty and vagueness” (Cordon, Herrera et al., 1996:136). Not only is fuzzy logic grounded in a long tradition of philosophical logic, there were already academic discussions in the early twentieth century about the need to deal more adequately with uncertainty than classical binary logic allowed². These early investigations into multi-valued logic were published in philosophical journals

¹ For instance: Mendel (1995:347) and McNeill and Freiburger (1993:103).

² Reiser recounts that the foundations of binary (true/false) philosophy are grounded in three laws of Aristotelian logic including the ‘Law of the Excluded Middle’, which does not allow for partial truth (Reiser, 1935:102). Thus, an example applying the Law of the Excluded Middle requires that answers to questions like ‘is this music loud?’ can be only ‘yes’ or ‘no’ answers, ‘maybe’ or ‘partly’ are not allowed.

rather than mainstream engineering. Perhaps this is why Zadeh, a computer engineer, seemed to be unaware of these antecedents.

These challenges to classical reasoning had become sufficiently interesting that their historical development was being documented in philosophical journals. Reiser observed in 1935 that challenges to the conventional binary logic system in philosophy began in the late 19th century with Hegel (Reiser, 1935:108), while by 1930 mathematicians Lukasiewicz and Tarski had published work on a logical three-valued system containing the possibilities of truth, falsity, and uncertainty (Reiser, 1935:111). However, academic papers in those times without internet search engines could easily be overlooked. For example, in 1993 Bart Kosko observed that Bertrand Russell was the first symbolic logician to write about ‘vagueness’ in 1923³ (Kosko, 1993:19). Moreover, historical accounts are always time-bound, because they cannot include materials published later. Several years after Reiser’s historical overview, Black’s paper on Vague Sets was published in 1937. Kosko suggests this paper might present the closest theoretical relative to fuzzy set theory (Kosko, 1993:19). Even though multi-valued logic remained in relative obscurity for some years, Gaines demonstrates that research and application of fuzzy logic grew exponentially in the decade following the initial publication of Zadeh’s paper (Gaines, 1976:626). A recent search using academic search tools shows this exponential trend continued until 2012 when it seems to have reached a plateau at around 7,000 new items per year (SuperSearch, 2016). The influence of Zadeh’s pragmatic approach to dealing with uncertainty has inspired an exponential increase in research for better ways to build automated systems that could classify fuzzy information and make complex decisions in uncertain environments.

Those that could embrace the pluralist philosophy behind fuzzy logic were quick to adopt the new approach. Kosko notes that Japanese corporations found fuzzy logic to be very practical and were quick to design and implement new systems using this new problem-solving method. In the 1980s ‘smart’ products became a commercial success in Japan, where large corporations quickly introduced fuzzy logic into a variety of domestic products. By contrast, fuzzy logic took at least another 20 years

³ Russell presented an address to the Jowett Society in Oxford, UK, which broached the topic of language as a vague descriptor of precise real objects. The text was reproduced in the first volume of *The Australasian Journal of Psychology and Philosophy* (Russell, 1923:84-92).

to be adopted by computer engineers designing systems and products in the West (Kosko, 1993:16-17). For example, Grossberg and associates developed an alternative form of machine intelligence, Adaptive Resonance Theory (ART) between 1976-1980 (Carpenter, Grossberg et al., 1991a:759). ART is a specific type of neural network⁴. Neural networks have been a focus of much research in artificial intelligence. Initially, neural networks only used binary, true or false, inputs, but by 1991, Fuzzy ARTMAP systems were developed which, given a fixed number of predetermined input variables, can form their own neural networks from scratch, within their own small domain of experience (Carpenter, Grossberg et al., 1991a:763). Naghdy, Wang et al. have built on this system to develop Feature Adaptive Fuzzy ART systems which expand the number of input variables in a systematic way, as the input data increases in complexity (Naghdy, Wang et al., 1996). This example demonstrates how technological advances in computer systems and growing commercial interest in replacing either the mundane or very complex human functions with machines, has brought increasing interest in fuzzy logic, and its practical implementation.

In 2015, Abbas, Zhang et al, outline five main approaches to computational intelligence, an extension of artificial intelligence, which enables the machines to make context-dependent decisions (Abbas, Zhang et al., 2015:668). Both fuzzy logic and ART (Neural) Networks mentioned previously are among these methods. The other three are Evolutionary Computing, Swarm Intelligence, and Artificial Immune Systems (Abbas, Zhang et al., 2015:668). As mentioned previously all these adaptive computational models are based on various natural systems and how their behaviour is conceptualised. For example, one mode of Swarm Intelligence computation is based on how bees are thought to interact in their communal-hive activity. However, fuzzy logic is the only method specifically designed to deal with the uncertainties of using natural (human) language.

⁴ Neural networks are conceived as a model of the human brain, which grows new and stronger linkages as it is given more pieces of information. By contrast, Fuzzy Logic is designed to model thinking processes, rather than the physical brain structure.

F.2 Concepts of Fuzzy Logic

The term ‘fuzzy logic’ is a confusing conflation of two new distinct, though related, ideas. Firstly, the theory of fuzzy sets, adds two new concepts to conventional set theory. The second idea is the mathematical logic with which fuzzy sets are manipulated when solving problems. These two ideas are important in establishing fuzzy logic a rational and efficient way to work with complex data⁵. Each idea is discussed below in separate sections.

a. Fuzzy Set Theory

Fuzzy set theory contains a hierarchy - Universes of Discourse, Fuzzy Sets, and Elements – which can be used to break imprecise information into manageable logical entities. This descriptive hierarchy enables more detail to be preserved about individual objects than conventional set theory.

The highest level descriptor is the ‘Universe of Discourse’, which broadly can be interpreted as one major dimension of data relevant to a particular decision-making task. For example, if the task is to distinguish music from speech then relevant Universes of Discourse might include ‘Packet Length’ to describe the duration of sound between silences, while another relevant Universe of Discourse might be ‘Decay’ to describe the way individual sound events terminate into complete silence. Alternatively, if the task requires describing the acoustic frequency range of music, then possible Universes of Discourse include ‘Pitch’, ‘Tessitura’, ‘Register’, ‘Frequency (Hz)’, each of which is quite similar but captures a different aspect of the actual sound. Deciding which term to use depends on the goal of the overall decision-making task. For example, if the bigger purpose of the decision model is to determine the tonality of music phrases then describing the acoustic frequency of the sound as ‘Pitch’ is the most suitable Universe of Discourse. Alternatively, if the larger decision task is to determine suitable singers for an aria then using ‘Tessitura’ or ‘Register’ would be most suitable.

⁵ Figure 5.1. Classification of Qualitative Listening Observations into Fuzzy Logic Entities (see Chapter 5, p.157) shows how these concepts are implemented in *Fuzzy IDEAS*.

At the next hierarchical level, each Universe of Discourse is described in more detail by its fuzzy sets. Each defined fuzzy set only contains those elements that are related to each other in some way. The number of sets depends on the level of detail required for each specific Universe of Discourse. For example, the entire spectrum of Register could be covered by only two sets such as 'High' and 'Low', or it could be covered by 20 sets each of which covers a given pitch interval such as a 'perfect fifth' or an equivalent acoustic frequency range in cycles per second (Hz). However, Pedrycz notes that limiting the number of fuzzy sets to between five and nine ensures that each individual fuzzy set remains clearly distinguished and easily accessible to human cognitive processes (Pedrycz, 2007:49). It is these elemental fuzzy sets that permit fuzzy logic to work with mathematical precision. Each Universe of Discourse does not have to be exhaustively covered by defined sets in order for Fuzzy logic (reasoning) to work. For example, if the analysis is focussed only on the 'Very High' register, then it is sufficient to only define three sets to cover the frequency range above 12,000 KHz. All other possible fuzzy sets in lower Registers can be ignored.

Binary classification requires 'quantisation' or rounding off to the nearest unit. During 'quantisation', information is lost, and complex things are over-simplified. Fuzzy set theory allows for the possibility of intermediate states, such as mostly right, partially true, light-grey, nearly Medium. This is achieved by a new concept of membership values to measure the relative accuracy of classification of each element in each fuzzy set. This important development maintains greater detail about each element and the system as a whole. These specific membership values can then be used in further calculation in a very precise mathematical way while maintaining a detailed representation of the system under discussion.

The basic proposition of fuzzy logic is that any one object has the possibility of belonging to all potential fuzzy sets within the relevant Universe of Discourse, but with varying degrees of membership. The membership value represents a sliding scale of truth, or the degree to which the specific quality held by this object belongs to each of the fuzzy sets relevant to this Universe of Discourse. For instance, 'Amplitude' is a Universe of Discourse that describes the loudness level. In this example, Amplitude contains three fuzzy sets: Soft, Medium, and Loud. According to fuzzy set theory, all fuzzy sets hold the same sound simultaneously. For example,

when a sound is described as Soft bordering on Medium, some uncertainty exists about its classification. Thus an Amplitude of 45dB will be included in Soft and in Medium but with different membership values, say 0.6 and 0.2, reflecting that 45dB is thought to be more Soft than Medium, but it contains some possibility of being Medium. In terms of mathematical representation, each element of a fuzzy set consists of two parameters: its pragmatic value and its membership value. For instance, this particular sound event is represented in the fuzzy set Soft by (45dB, 0.6), and in Medium the same sound event would be represented by (45dB, 0.2). According to fuzzy logic principles, a 45 dB level is theoretically included in Loud, but in practice, 45dB is not considered to be loud, so 45dB level has a membership value of zero in the fuzzy set 'Loud' (45dB, 0). It is common practice among fuzzy logic users to minimise computational effort by omitting mention of those elements that have a membership value of zero within a given fuzzy set. Hence, in practice, the set of Loud would not be included in calculations for this particular sound event.

Conventional set theory becomes a special case of fuzzy set theory. In conventional set theory, an object has only binary possibilities of right or wrong, true or false, black or white, on or off. Therefore, this object is in a conventional set or it is not. Thus, the membership value of any given element in conventional sets can only take one of two values: 1 if the element belongs to a conventional set and 0 if it does not belong. Thus in conventional set theory, borderline cases, such as a 45dB sound could only be classified into only one set, thus classified as Soft (45dB, 1) and in both Medium and Loud (45dB, 0). Similarly, to fuzzy set theory, if an element has a membership value of zero in a given set, then any reference to that element in that set is omitted. As a result, conventional set theory has not required membership values to be defined or spelt out in detail.

b. Fuzzy Reasoning

Describing the reasoning mechanisms in fuzzy logic as 'fuzzy' is a complete misnomer, because the logic is not fuzzy, but a precise and carefully detailed system based on conventional mathematical principles of logic, which produces meticulous and useful outcomes. Fuzzy logic alters the reasoning mechanisms applied during conventional mathematical calculations in order to address the addition of a membership value to each element in each fuzzy set.

The theoretical mathematics for fuzzy logic has developed separately from the practical application of fuzzy logic to industrial problems. This work to establish the mathematical theorems recognises that fuzzy logic does have a solid conceptual foundation, despite the challenge it offers to conventional mathematical logic based on the Law of the Excluded Middle. Because this Law is a core foundation of our conventional mathematical theories developed over centuries, using multi-valued logic means re-thinking many mathematical precepts. The idea of simultaneously manipulating variable truth values is easy to grasp conceptually, since humans routinely do multi-valued thinking in every-day life. However, building a robust axiomatic mathematical system, which contains and sustains multi-valued logic, is a work in progress. This is demonstrated by two of the many publications debating the merits of various inference engines: Patel (2002) discussing the effect of shifting set boundaries on reasoning mechanisms in different problem solving situations and Precup and Hellendoorn's (2011) survey of the state of the art of inference engines . In the fuzzy logic engineering world, reasoning systems are called 'inference engines' to reflect their background in mathematical logic. Many different inference engines have been developed based on different ways of dealing with the challenges to mathematical conventions made by multi-valued logic.

Fuzzy logic systems can be symbolically represented in a variety of different ways, such as graphs of numerical functions, or as matrices of numbers, or as Venn diagrams, or as mathematical equations. However, they all have the same underlying methods and principles.

F.3 Distinguishing Fuzzy Logic from Probability Theory

What probability theory does very precisely is describe in a very specific and complex way the relations, or connections, between two events. Probability is about the likelihood of a particularly well defined specific event occurring. Likelihood relies on past experience to guess a yes/no answer to whether a future, thus unknown, event is likely to be 'Loud' or 'Medium'. Probability theory assumes that the connection between past and future is not completely controllable. Even when the connection can be limited to a particular range of possibilities, the underlying assumption is that each specific future event remains unpredictable. If this

assumption is not true, then the connections would be certain, and there would be no need for probability theory.

The essential underlying premise of fuzzy logic systems is that some specific object is hard to classify in the 'either-or' system of science and binary computing and probability theory. Fuzzy logic describes the range of possibilities inherent in each event as they exist in their imprecision and ambiguity, saying that both or many truths can coexist. A fuzzy logic framework ensures that those features that contribute to uncertainty in classification are adequately described and maintained, so that an aural event can be both 'noise' and 'music'. Probability theory is concerned with choice, with determining which attribute is most likely to be true. Probability theory is still based on binary thinking, in which something is either true or false. As discussed previously, binary classification requires 'quantisation' or rounding off to the nearest unit. For example: this aural event, according to binary thinking, must be classified as either one or other of 'noise' or 'music', so that event clearly is classifiable as a yes/no answer, for example if this sound event has 75% inharmonic overtones then it must be 'noise', it cannot be 'music'. In this process, information is lost, and complex things are over-simplified.

Fuzzy logic is a good method for describing music, because it enables a thorough explanation of imprecision. Fuzzy logic describes the qualitative uncertainty regarding the nature of each event, and it can also be used to describe the relations between events. Using probability theory to describe music requires a prior search for well-defined descriptors. Probability theory cannot describe the features of events themselves. What probability theory provides is a well-defined particular relationship, or connection, about the likelihood of concurrence of two precisely defined events. This process is self-limiting, and eliminates information vital to music, which thrives on ambiguity and uncertainty as an intrinsic part of the compositional design.

Fuzzy logic rule sets are simple, intuitive and transparent rather than complex abstracted incomprehensible mathematics and formulae. Representing complex systems with probability models requires precise modelling of the complete range of variables in the system, which quickly produces convoluted mathematical procedures requiring intense numeric calculation. Rather with fuzzy logic, the

system emerges through experience. Rather than requiring a prior mathematical model with the precise specification of all variables, and associated causal relationships, fuzzy logic approximates non-linear systems to any required degree of precision through iterative fine tuning. This is not to imply that fuzzy logic systems do not require some prior decisions regarding appropriate variables and their interaction. However, knowledgeable input from a single expert is sufficient for developing fuzzy logic systems, rather than extensive data collection of many observations required to provide accuracy of probability distributions. Instead, Membership values represent a rating of how much each event is thought to belong to each fuzzy set. For example as a number of different aural events are experienced and rated by one analyst-listener, a 'music' set is developing, as is another one for 'noise'. Within the 'noise' set, each individual aural event is associated with a membership value to represent how much that sound event is thought to be 'noise', and in the 'music' set, the same aural event is given a membership value that represents how much that particular sound is thought to be 'music'. These ratings can be precise numbers (e.g. 0.6, or 0.4), or simply be 'ordinal' (e.g. somewhat, or very much)⁶. However, as long as the method of ranking is consistent across fuzzy sets in the given problem, fuzzy logic permits both types of membership values to be used for further calculation in a very precise mathematical way

F.4 Existing Commercial Applications of Fuzzy Logic

Fuzzy logic has been used in a broad range of practical applications including modelling consumer preferences for foods ranging from biscuits (Chevrie and Guely, 1998:24; Chu, 1999) to olive oil (Santosa, 2010). These models are multi-dimensional, combining several unrelated factors as well as the interaction between factors to enhance production processes or build marketing strategies. Fuzzy logic has also been successfully applied to provide a semi-quantitative method to evaluate coastal scenery using the opinions of environmental experts and users on the effects of both man-made and naturally occurring physical features (Ergin, Karaesmen et

⁶ See Quick Reference Guide for definitional information on this mathematical term.

al., 2004). Engineers have applied fuzzy logic to automate mechanical systems⁷ (otherwise known as robots). Examples of industrial systems which use fuzzy logic to optimise inputs while providing quality outputs include the first application to control a steam engine (Mamdani, Ostergaard et al., 1984), to cement production in Denmark (Precup and Hellendoorn, 2011), among other manufacturing and computer systems (Kaehler, parts 1-6). Other examples include using fuzzy logic to automate the Sendai City (Japan) subway system (Kosko, 1993:175), regulate air-conditioning; automate welding; in aircraft flight control; game playing by computer opponents; and biological processes (Cordón, Herrera et al., 1996:142).

On a more personal level, fuzzy logic is also used to make automatic adjustments in 'smart' consumer appliances such as washing machines, cameras, rice cookers and microwaves (Cordón, Herrera et al., 1996; Yen, n.d.) or focussing of camera lenses (Kosko, 1993:175). These control systems use fuzzy logic algorithms to automatically adjust processes based on data input from various sensing devices to take into account factors incorporated into human thinking in these situations. For instance, a fuzzy-controlled washing machine uses a laser beam to measure the cloudiness of the washing water, as this implies more dirt in the clothes, which influences the wash cycle to continue longer than if the water is clear.

⁷ Over time the terminology for, either partially or fully, automated control of physical systems, whether using fuzzy logic or some other mathematical system, has changed from cybernetics, to robotics, to Artificial Intelligence. They all refer to machines that perform tasks without human intervention beyond programmers setting limits on the range of performance.

Appendix G. Timeline of Music Research using Fuzzy Logic

As mentioned in the body of the thesis, the literature review on the application of fuzzy logic to music problems is the most comprehensive review of fuzzy logic and music to date, and is one of the significant contributions made in this thesis. Table G.1 below sets out the publications year by year, to show how most research is independent of any other work. Table G.1 contains information on the discipline in which the research was conducted and a description of the research problem. Some papers have been self-published, but the research was conducted within academic contexts. Others simply mention the relevance of fuzzy logic as a possible method to enhance other projects, without actually applying fuzzy logic in practice.

Table G.1. Timeline of Music Research using Fuzzy Logic

Year	Authors	Background	Subject Area
Published 1992	Vidyamurthy, & Chakrapani	Computer Science and Applied Mathematics	Algorithmic composition of variations requires feature detection. This is a similarity problem. Uses fuzzy logic to describe a note by its frequency spectrum and then compare two notes to find similarity. This is done for each note in a melodic fragment to tell which is the main note which is then identified as the tonal centre for that fragment.
Presented and published 1995	Bresin	Computer Science	Applying fuzzy logic to the KTH rules for expressive playback of already composed MIDI music.
Webpage 1995 revised 2011	Elsea	Audio Technology	Max/MSP patch for automated generation of Melody or Chords in tonal music using MIDI.

Year	Authors	Background	Subject Area
Published 1997	Quinn	Music Theory	Underlying research problem is automated listening for recall of similar materials. Set up as a pattern matching/similarity problem on melodic shapes. Comparison of 11 note monophonic melodic fragments for similarity based on existing contour theory using matrices and averages. In fact the fuzziness is only an idea rather than applied in practice to compare the relative values of individual notes. All comparative values are either set at 0 or 1, laid out and manipulated as conventional truth tables.
Published 1998-2001	Arcos and de Mantaras	Artificial Intelligence Engineer	Flags fuzzy logic as extension of current work into 'expressive' playback of pre-recorded monophonic audio.
Published 1998	Tokamaru, Yamashita, et al.	Artificial Intelligence Engineers	Uses fuzzy logic as the reasoning process to determine chord progressions for a real 40 bar Latin melody. The idea is to address the ambiguity in correct chords presented by music theory, and to take human expressiveness into Genetic learning algorithms to generate each parameter and then to control it as the melody unfolds, through a feedback system where the chosen harmony affects the membership functions which affect the chosen harmony. Highly mathematical, model but has 80% success rate, and will use linguistic model in future work. Has not been able to deal with the peak moment of the music when the harmony does not follow the rules.

Year	Authors	Background	Subject Area
Published 1999	Kostek	Computer Science	Fuzzy logic applied experimentally to enable several physical organ pipes to be more responsive to player's expressive requirements during live performance using a MIDI interface. Other applications of fuzzy logic include music retrieval designed around automated recognition of acoustic instruments and recognition of melodic phrases in an audio stream. Fuzzy logic has also been applied to evaluate the acoustic qualities of two types of software. One is designed to emulate acoustic qualities of architectural spaces, and the other is a range of audio compression algorithms such as MP3.
Presented and published 1999 and 2002	Milicevic	Audio Technology	Concept paper of a fuzzy logic engine to satisfy listener demands by evaluating the aesthetic qualities of computer music prior to performance.
presented 2000 published 2002	Arcos and de Mantaras	Artificial Intelligence Engineers	Uses fuzzy logic to aggregate the expressive data from cases previously stored in a database to affect the playback of pre-recorded monophonic audio stream: SaxEX.
Web self-published 2000-2004 audio recording self-published 2008	Raes	Composer designing and using automated composition engine	Used fuzzy logic on MIDI note data of pre-composed simple melodies to generate tonal harmonies as test of concept (in music terminology this is a 'Study').
Published 2002	Monti and Sandler	Computer Science	Uses fuzzy logic to locate individual notes in an audio stream of instrumental music.

Year	Authors	Background	Subject Area
Published 2002	Whalley	Composer designing and using automated composition engine.	Outlines the conceptual use of fuzzy logic as controller of an automated composition engine that uses and produces MIDI data.
Published 2003	Weyde and Dalinghaus	Music Technology and Cognitive Science	Goal is music retrieval from databases of scores. Using fuzzy logic to assess the 'precision' and 'correctness' of input rhythm motifs of 4-5 notes against given groups based on listener perception and music theory. Uses MIDI note information. Modular so extensible to other music parameters.
Published 2004	Friberg	Audio technologist working in the field of performance art.	Fuzzy logic used to analyse incoming audio and video for expression cues in real time to allow a dancer to control the expressive qualities of the music: the <i>Groove Machine</i> .
Published 2004	Kostek	Computer Science	Is concerned with Music Info Retrieval, based on instrument sounds and phrase recognition of melodies. Mentions fuzzy logic as one among many methods of compressing real time data. Choice of method depends on data type. Inputs data is sampled real sounds for instruments, and MIDI data for phrase recognition. Input data is monophonic and Only one style of music: Bach Well tempered clavier.

Year	Authors	Background	Subject Area
Published 2004	Weyde This paper is complementary to 2003, but 2003 has more detail on the fuzzy logic part, this one has more detail on the system design and the input variables are better defined.	Music Technology	Compares sequences of input notes against models at motif and phrase level rhythms so monophonic MIDI input.
Web self-published 2004	Sorensen and Brown	Composers designing modules for automated composition engine.	Using fuzzy logic to translate the linguistic commands of composer into numerate form to control the amplitude of either audio or MIDI streams using Java. Designed as a module to plug into their own composition software.
Published in Romanian 2005 Not available in English	Ciocan cited in Rădulescu, 2012	Composer and musicologist	Attributed with using fuzzy logic as one mathematical and logical representation of music as one tool in his semiotic theory of music interpretation.
Published 2005	Camurri, De Poli, Friberg, Leman and Volpe	Digital audio and video technologists, working in the field of multi-media interactive performance.	Explains the MEGA project, and the role that fuzzy logic plays in several of the research questions: mapping movement to expressive control of audio playback, and mapping three attributes of music to different emotions, following on from Bresin's 1995 application of fuzzy logic to KTH rules.
Published 2005	Cope	Composer designing and using automated composition engine	To analyse already composed music using MIDI note data to categorise individual notes into chord types, using LISP programming language.

Year	Authors	Background	Subject Area
Published 2005	Lindstrom, Camurri, Friberg, Volpe, Rinman.	Digital audio and video technologists, working in the field of multi-media interactive performance.	Mentions the work by Friberg on extracting expressive cues from audio and video, which is applied to control three attributes of the music in the <i>Groove Machine</i> and also to <i>Ghost in a Cave</i> : an interactive game where players control the video and the music by their voice or movements.
Self-published webpage 2006	Garrett	Music technology composer	Uses fuzzy logic to translate weather data into music in real time using Elsea's Lobjects in Max/MSP.
PhD thesis 2006	Cadiz	Composer designing and using automated composition engine.	Developed a platform that can be used across sound synthesis methods based on Max/MSP or Pd, which uses fuzzy logic to control various aspects of audio streams to make new digital compositions.
Published 2006	Cadiz		Using fuzzy logic to map visual data to control sound synthesis engines to produce music.
Published 2006	Cadiz and Kendall	Composer and computer programmer designing and using automated composition engine.	Sets out how the fuzzy logic module developed for Max/MSP and Pd to control various sound synthesis programs using the same interface via MATLAB, with rules to fuzzify crisp inputs and defuzzify outputs after the rules have been applied to map several inputs to diverse numbers of outputs.
Published 2006	Cope	Composer designing and using automated composition engine.	Adaptation of Elsea's 1995 work from Max/MSP to LISP to generate chords and good voice leading in automated composition.

Year	Authors	Background	Subject Area
Published 2006	Friberg, Bresin and Sundberg	Audio technologist and programmers working in the field of performance art.	Mentions the work by Bresin (1995) to apply fuzzy logic to KTH rules as a significant point in the development of those rules.
Published 2006	Kiendl, H., Kisellova, T. & Rambinintsoa, Y.	Computer science	Using music as a way to test use of complex fuzzy logic models. Uses MIDI note data on <i>Fur Elise</i> to model expressiveness. Their work in principle seems to be replicating the KTH rules, but without acknowledgement and so far without success as they say their model still needs more work.
Published 2006	Muñoz-Expósito, J. E., Ruiz-Reyes, N., García-Galán, S. & Vera-Candeas, P.	Tele-communication engineers	Concerned with discriminating between speech and music. developing a more efficient way with fuzzy logic assessment of spectral content using only three variables: mean, variance and skewness using spectral information from Bark Scale with only three valued fuzzy sets. Analyses audio stream in real time.
Webpage 2007-2009	Bonardi and Truck	Artificial intelligence engineers working in performance art	Using fuzzy logic to control any or all parameters of either audio or MIDI streams using Java. Designed as a module to plug into Max/MSP.
Published 2007	Dahl and Friberg	Audio technology for speech and performance art including music.	Flags using fuzzy logic in future work as a more accurate way of representing the input data stream of performance gestures by musicians (not sound) as opposed to an arithmetic moving average.

Year	Authors	Background	Subject Area
Published 2007	Eigenfeldt	Computer Music composer	Use of his Kinetic Engine to make Drum Circle which is an interactive set of intelligent agents playing percussion. Uses fuzzy logic to control the overall note density of the ensemble, by determining both when each agent plays; by determining the global density at any moment and feeding that back to the agents to determine how many notes an agent will play; and by determining where those notes will fall over a measure (including all relevant beat subdivisions as possibilities. Builds on Elsea's work in Max/MSP and uses similar vectors but for note position in the bar rather than note position in a scale or chord.
Published 2007	Eigenfeldt This paper is a follow on from a different angle than the previous paper just above.	Computer music composer	Is another example of Drum circle (see immediately below) but includes less detail on the fuzzy logic and more on the ideas of interactive intelligent agent systems... so these ideas are more clearly laid out, along with the background knowledge impetus for doing the research. Except that fuzzy logic is also used to control global tempo, meter and note subdivision for each new composition: this was not mentioned in Drum Circle paper.
Published 2007	Sindberg, L	Musicianship pedagogy	Only uses 'fuzzy' as a modifier of her classification of student understanding of teacher intentions. It is just a bald definition of the times when students are unsure of what the teacher actually wants from them. There is no development of the concept or any further use than as a middle classification label.

Year	Authors	Background	Subject Area
Presented 2008 Published 2010	Molina-Solana and Arcos	Artificial Intelligence Engineer	Flags using fuzzy logic in future work on the identification of individual violinists solely on the basis of their recordings.
Published 2009	Park D-C	Informatics	The purpose is for efficient music retrieval.. and it is a type of classification problem. Using fuzzy logic to calculate prototype materials based solely on the frequency over time so that there are different peaks at different times, using the frequency spectrum translated into MEL bands in various time windows across the audio data. The prototypes are then compared to 30sec audio clips to recognise if audio files are classical, hip-hop, jazz or country.
Published 2009	Yilmaz and Telatar	Electrical Engineers	Used fuzzy logic on MIDI note data to provide contrapuntal part to a pre-composed <i>cantus firmus</i> .
Published 2010	Măniuț	Musicology	Refers the conceptual use of fuzzy logic to understand the ideas in contemporary music. Although fuzzy logic is mentioned only as an example in the bigger argument that mathematics and art are related but different ways of investigating the dimensions of music including the spiritual dimension.

Year	Authors	Background	Subject Area
Published 2010	Yilmaz and Telatar	Electrical Engineers	Problem is to automate a four part chorale harmonisation of a pre-composed monophonic melody using MIDI pitches. Using fuzzy logic to introduce a human dimension, or inexactness of the result, to add aesthetic appeal. This paper builds on the two part harmonisation paper previously built and seems to work to the satisfaction of human listeners... the test is on an 4 bar two chord per bar harmonisation of a bass melody. It seems much more thought out than their first paper... and it seems to work!
Published 2010	Eigenfeldt and Pasquier	Composer designing and using automated composition engine.	Designing a system to compare sound samples for real-time performance. Implemented in Max5. Develops similarity measures on timbre as measured in Bark Bands. Generates what he calls a fuzzy list for comparison. The recall of samples for comparison happens in real time but the initial mark-up of the spectral content occurs prior to performance.
Published 2010	O'Sullivan and Boland	Computer Science	Using fuzzy logic applied to humanise the output of digital drum machines, uses MIDI data.
Published 2011	Eigenfeldt	Composer designing and using automated composition engine.	Fuzzy logic is applied to ensure there is sufficient motivic variation in the output of the composition engine which uses MIDI data to control robot performers playing percussion.

Year	Authors	Background	Subject Area
Webpage 2011	Garrett, Richard	Music Technology	This is a single module in software which generates MIDI events in real time. The texture controller is fuzzy, but depends on how many voices are already playing at any one time compared to a maximum threshold. MIDI based modules to plug into <i>Ableton Live</i> .
2012	Arcos Expanded book chapter republication of 2000/2002 papers on <i>SaxEX</i>		Expanded explanation of using fuzzy logic to aggregate the expressive data from cases previously stored in a database to affect the playback of pre-recorded monophonic audio stream: <i>SaxEX</i> .
Webpage 2012	Kosona and Hadjileontiadis	Informatics	Proposal for Fuzzy categories along with Catastrophe Theory to analyse Xenakis' instrumental music: <i>Achorripsis</i> .
Published 2012 Revised 2013	Leon and Liern	Mathematics	Pitch in real time performance of violin and saxophone is not fixed but is variable which can be adequately described by fuzzy logic. Revised version does not use violin but more extensive testing on saxophone playing. Uses audio files and commercial software for analysing frequencies, their main concern is the development of a good similarity measure using fuzzy logic.
Published 2012	Heister	Musicology: History	Flags conceptual use of fuzzy logic to analyse motivic variation within a single piece of music.

Year	Authors	Background	Subject Area
Published 2013	Arcos, J. L., Guaus, E. & Ozaslan, T. H.	Artificial Intelligence	Fuzzy logic is used in guitarLab: analysis of classical guitar practice sessions. Analyses monophonic audio stream of performance for rubato, loudness and timbre. Analyses the score at note level, motif level and phrase level for metrical strength, grouping into motifs and phrases, by using timing and loudness information. Then compares performance to score to find out how the performer deviates from the score, and also from one section of the music to the next. Uses fuzzy logic in visually representing the outcome of the comparison.
Webpage 2013	Cycling'74: programming and distribution of Max5:wiki.	Computer programmers	'Modal fuzzharm' is a module in Max5 which enables the harmonisation of input notes using MIDI
Patent application 2013	Roberts, Hyman et al., 2013 for Gracenote.	CDDB Software commercialisation by Gracenote	Gracenote have, for the first time, included references to fuzziness in this patent application without specifying what that actually means. Verification of matches by track length is 'fuzzy', while the fingerprinting process which takes the frequency spectrum over a short sample of the music, has been extended to include multiple fingerprints from one recording which are then fuzzily joined together to make a longer fingerprint record. What fuzzy means in these contexts is unspecified.

Year	Authors	Background	Subject Area
Webpage 2014	Cycling'74 programming and distribution of Max5: blog	Music technology crowd source	1 some remarks are about the conceptual use of fuzzy logic as a controller. 2. the majority of remarks are referring to Elsea's harmoniser Lobjects he developed in 1995 as a current, relevant, useful tool to implement in Max5 for solving harmonisation problems.
Published 2014	Chau	Music Pedagogy	Explores three different ways that computers contribute to music pedagogy, noting that the development of fuzzy logic and artificial intelligence could allow higher level use of computers in music teaching and learning than is currently the case.
Published 2104	Marinos and Geiger	Technology applications in Multimedia	Explores the automated development of fuzzy logic rules based on mapping examples of a human conductor's predetermined movements to control a MIDI stream of three attributes (tempo and time signature, and volume) of a digital piano, that accompanied a human pianist during a live performance. Fuzzy logic allows the rules to be transparently accessible to non-technologists.
Published 2015	González, Cuadra, and Cádiz	Multi-media programmers designing automated playback systems.	Use of natural language descriptors and application of fuzzy logic to classification of music that exhibits characteristics of different genres, so that each piece of music can have an appropriate EQ setting for playback.

Year	Authors	Background	Subject Area
Published 2016	Kreković, Pošćić, and Petrinović.	Engineering and Computer Science	Limited to timbre, a fuzzy logic controller using 57 rules as an interface for for any digital synthesiser based on Virtual Studio Technology (VST). The interface automates the numerical settings of attributes of digital sound synthesis when the desired timbral qualities of the sound to be used in performance are specified using one or more of seven predetermined adjectives to describe the (yet to be) synthesised sound.

Appendix H. Evaluation Procedural Documents

This appendix contains three documents provided to the participants to enable them to make informed decisions about participating in the evaluation:

1. Information Sheet and Consent Form. The Information Sheet explains the purpose of the testing and the significance of their responses to my research, and their consent requested to a much wider range of data than was actually collected
 2. the Listening Instructions Document
 3. Answer Sheet used for collecting the qualitative listening observations during the test process.
-

H.1 Participant Information Sheet

Researcher:

Wendy Suiter
PhD scholar,
School of Music,
Research School of Humanities and the Arts,
College of Arts and Social Sciences,
Australian National University

Project Title: *Fuzzy IDEAS*: listener-oriented music analysis

General Outline of the Project:

I will ask you to provide written responses to two pieces of music presented for listening by myself using digital files on my laptop computer. The listening experience will resemble as closely as possible a real concert-style experience.

I will also ask you a few questions at the beginning and end of the listening, to get feedback from you about using *Fuzzy IDEAS* approach.

I will also take observational notes on how you are engaging with *Fuzzy IDEAS* techniques, to observe any difficulties with the method in practice.

I may also take a video recording of you while you are listening to the music, to enable a more detailed analysis of your responses if my written observations are insufficient.

If you attend the research venue, sign a written agreement, listen to the music and actively provide your written responses then you will have consented to participate in this research and for your responses to be used in reporting the results of this pilot project.

Use of Data and Feedback:

You will only be identified by a pseudonym.

No photographs or video will be included in any publications, including my thesis. Written details of your de-identified responses recorded on video may be included in written text, and will be treated identically to the written notes I take during the testing, and your own written personal responses.

Your written responses about the music will be transcribed into an Excel spreadsheet so your handwriting cannot be identified. Later, I will convert the data in the Excel spreadsheet into a graphical representation that will remove any personally identifying information from the listening observations. Any personal information that could identify you from your responses will not be included in any of this digital transcription.

Any personal information that could identify you personally, arising from your written or video-taped responses to my interview questions will not be included in any digital transcription. I will send you a copy of the digitised version of your own notes and my field observations, for your comments before your responses are incorporated into my research.

Your anonymous digitised responses to which you have given your approval, will be reported in my thesis, which will be publicly available in the ANU library, and associated research publications, arising from the research.

Your participation in the project is voluntary and you may, without negative consequences, decline to take part or withdraw from the research without providing

an explanation at any time until the work is prepared for publication. If you do withdraw, your responses and my analysis of those responses, will be destroyed and not used.

You can refuse to answer any question at any time.

You may refuse to be video-recorded at any time.

The research will take place in the Kingsland Room in the School of Music, at a date and time mutually agreeable. You will only be required to attend once to listen to both pieces of music. Taking into consideration the time for me to explain what is required, to conduct the pre-listening and post-listening interviews and listen to the music, the maximum time required is 90 minutes.

There will be no remuneration for participating in this project.

Risks:

This is a very low risk activity in terms of personal injury, as the listening experience will be as comfortable and naturalistic as possible, with the music playing at reasonable volume through loud speakers in a large room.

You might be uncomfortable describing or having someone watch or video your personal reactions to the music. Should this occur you are free to stop at any time or to ask the researcher to stop observing or video-recording your reactions.

If you are finding writing or typing difficult, then we can stop the procedure at any time. Should you experience any physical discomfort, then I will advise and support you to seek the services of the University Health Service, or your own personal health practitioner.

It is unlikely that you will personally benefit from participating in this research, but I expect that this research will improve understanding of whether active and self-reflexive listening techniques can provide greater insight into and enjoyment of avant-garde music. I expect this understanding/knowledge will enhance academic study of music (musicology) and the way composers are taught their craft.

Only I will have access to the direct material you provide.

My supervisors in their capacity as paid ANU academic staff, in order to ensure that my thesis meets suitable quality standards, will have access to the processed anonymous report written by myself. Your data will be kept confidential during both the collection phase and in the publication of results in my thesis, and any associated publications.

The written data and video recordings (if any) will be stored in a secure filing cabinet in my office to which only I have the key, and the digitised coding of results will be stored on my personal computer, and my personal share of cloud storage on the ANU servers.

Once publication has occurred the data will be destroyed.

Contact Details for More Information:

If you would like more information or have any queries regarding the study, you are most welcome to contact me directly: Wendy Suiter, School of Music, ANU.

The ethical aspects of this research have been approved by the ANU Human Research Ethics Committee.

If you have any concerns or complaints about how this research is conducted, please contact: Ethics Manager

The ANU Human Research Ethics Committee, The Australian National University

WRITTEN CONSENT for Participants

Fuzzy IDEAS: listener-oriented music analysis

I have read and understood the Information Sheet you have given me about the research project, and any questions and concerns about the project, listed below, have been addressed to my satisfaction.

(questions or concerns:

I agree to a video-recording being taken while I listen to the music. YES

☐ NO ☐

I agree to participate in the project.

YES

☐ NO ☐

I agree to be identified in the following way within research outputs:

Pseudonym YES ☐ NO ☐

No attribution YES ☐ NO ☐

Signature:.....

H.2 Instructions for listening

Please write your answers to the questions on the sheets provided.

Firstly, about your prior experience with avant-garde music.

Then before I play you a piece of avant-garde music I will give you the title of the music, and the composer's name. Please write down how this influences what you expect to hear.

Then the music will be played through from beginning to end, while you note down the time point and your observations about the music at that time. Your observations could include anything that stands out to you in the music, whether the quality of the sounds, or your own ideas and thoughts about the sound of the music. The idea is to listen as you would in a real concert-style experience, where, in theory at least, you are not doing anything else than listening to music. What is different here is that I am asking you to record anything you notice about the sounds or the silences or your reactions as the music is playing. If something stands out or occurs to you in the next part of the music while you are still writing, just stop and move onto the new observation.

After the music is finished, I will also ask you a few questions about your initial impressions on how this piece of music whether and how the music might make sense.

Finally, I will ask you a few questions about how difficult doing these tasks has been, and how they have impacted on your thoughts about the music you have just heard.

H.3 Answer Sheet

Before listening:

1. Do you dislike avant-garde music?

2. How much avant-garde music have you heard previously?

3. In what settings have you heard avant-garde music?

***Scharlachrote Buchstaben* composed by Barbara Heller, 1984**

1. What do you think the name of this piece tells you about what you are going to hear?

2. Have you heard any other music by Barbara Heller?

3. Do you have any expectations about what you might be about to hear?

4. Where do you get those ideas from? (the composer's name?, the date the music was composed?, or ???)

As the music plays, write down the time you notice yourself thinking about something, and then write down anything that occurs to you about yourself or the music, including any reactions or thoughts or anything you have noticed about the actual sounds of the music. If you don't have time to write everything before your next thought or noticing something about the sound of the music, then just stop; write down the new time and start writing down the new thoughts.

Start of the
Music: 0'00"

Immediately After listening:

1. Please write down your immediate thoughts or impressions regarding any ideas being communicated by this music, or any way this music has impacted on you or your reactions.

2. Does this music make any sense?

3. How does or doesn't this music make sense?

4. What do you think the composer was trying to do in this music?

5. Can you identify anything in the music that gave rise to your thoughts about this music?

After listening to the music:

A. About the testing experience:

1. Did you have any problems with the test process? Please write down any difficulties you experienced in documenting your listening observations here.

2. What do you think about that whole experience of documenting your thoughts, ideas and reactions to the title of the music, the composer, or anything else you may know or have thought about before listening to the music?

3. What do you think about that whole experience of documenting your thoughts, ideas and reactions to the sound of the music, as well as noting the times you reacted to the sound of the music, while you were listening?

4. Were there any benefits to you in doing this documentation?

5. Were there any drawbacks to you in doing this documentation?

A. About this experience of listening to avant-garde music:

1. What do you think about that whole experience of listening to avant-garde music?

2. Was it different from any other time you have listened to avant-garde music?

3. How was it different?

4. What made it better? Or worse?

THE END!

THANK YOU FOR YOUR TIME AND ATTENTION!

Appendix I. Evaluation Test Results

This appendix provides the listening test results and evaluation of the test method by each of the three participants. The results are presented in a lot of detail, as it shows how keen the participants were to understand what they were doing and to help with my research.

The evaluation was still concerned to find out responses to the test method, as well as the design of the coding methods, and a limited snapshot of results for each of the respondents. The key importance of the presentation of test results is the fuzzy visual representations and their utility for music analysis and feedback to composers and potential applications. The aim of this section is to draw out the commonalities and differences in these two additional tests, and where appropriate, are also considered in conjunction with the results from my own demonstration and the evaluation detailed above. Here, distinct details of the additional studies are only provided where necessary to highlight differences, while most results from the evaluation are summarised.

I.1 Test Administration

Music training

TS1 is a non-musician

TS2 is a non-musician

TS3 is a trained musician/composer

Liking for and knowledge of avant-garde music prior to listening.

TS1 loathes avant-garde music, even though she has heard a lot of it over the years.

TS2 likes avant-garde music, especially avant-garde pop music. “I enjoy the surprises and the skill avant-garde musicians display in communicating complex ideas.” She has heard “only some avant-garde music”, yet in a vast array of settings from concerts, galleries, to personal listening in the car.”

TS3 “I actually like/enjoy avant-garde music, although some of the personalities of the avant-garde have been overly serious about music” and he has heard “volumes” of it in a vast array of settings.

Test Playback and Documentation Technology

TS1 used an app on her own mobile phone to measure the elapsed time for each observation. This could be slightly problematic in not having the same equipment for every test participant then there is a problem synchronising time-points across participants.

TS2 was tested using her own smart phone timer, but wanted me to cue her in with a countdown. The playback equipment in this case was my laptop using windows media player. There was a delay between my pressing go on countdown to zero on the computer and the audio file loading, because I had been stuck in the lift immediately prior to the test, my setup time was limited so I hadn’t cued the music into the media player. This may make a difference, as TS2 pressed go on the timer exactly on countdown zero. TS2 asked me if it was the end only because I stood up to check if it was the end as I was myself uncertain and the computer screen was too far away to read.

TS3 was tested using a DVD player and audio setup as the play-back device. There were some problems with the audio in the test... about 2/3rds of the way through, perhaps the third or second last section with all the whirling chaotic sounds, the quality of the play back deteriorated to ghost sounds scratches and clicks which continued until the end, which sort of distorted the clarity of the piano playback... again no-one commented and I hoped this did not influence TS3s responses. The console was not in view during the listening test because of the room set up, so TS3 had to use a different timing mechanism. He was given the stop watch timer on my smart phone to tell the elapsed time, and started the timer on my cue to begin. I also cued TS3 some seconds after the end of the music so that he would not be left sitting in limbo, however, he verbalised it was the end of the music at exactly the same time.

Anxiety and reassurance required

TS1 apologised for her handwriting and bad spelling several times

TS2 observed that the questions were very revealing. I told her there were no right or wrong answers, and she was reassured that it was a test of my test method, not her answers. She checked this with me twice.

TS2 also observed that she did not have much music vocabulary, and excused her spelling by saying she was dyslexic. I pointed out that most people don't have much vocabulary that is specific to music. She also wrote that she was very conscious of her handwriting and spelling, feeling shame, fear and expecting judgement.

TS3 wrote a lot in the final questions, and did not need at all the amount of reassurance compared with my other test subjects. Only issue was TS3 didn't bring his reading glasses which made writing a bit more awkward and time consuming than otherwise would have been the case. TS3 was helpfully trying to make things work throughout the test, e.g. when I was looking for a pen to write my notes he offered to go and get one from his office.

How long is the test music going to take?

TS1 asked this question, as she was concerned about being held captive.

TS2 asked this question, as she was concerned that there might not be enough room to write everything down. I advised her to use the back of the sheets if she needed more room to write things down.

TS3 asked this question, without any explanation.

Signalling the end of the music

TS1 asked for a clear signal about the end of the music. We both became aware of needing to have a prearranged signal for the end of the music not simply sit in silence for a long time, so the respondent would know they could stop paying attention...particularly relevant in avant-garde music which can easily include ending gestures when it is not the conclusion and different to other listening

situations because the playback did not move onto the next track, nor any applause or performer gesture to indicate the end of the music.

TS2 did not clearly identify the end of the music from the sound of the music alone, particularly at the end of the music it was not clear that she had identified the end of the music before I signalled to her, well after the music had ended that it was the end... in fact this could have been because of her desire to get it right, and also her open-minded approach to the experience of listening to this unfamiliar music.

TS3 by this time I had become accustomed to the idea of signalling the end of the music, so after some time of silence at the end I said it was the end, just as TS3 also said I think that is the end.

How much did they talk or read

TS1 was an avid reader of my instructions and forms, with no desire for me to explain verbally as I had expected to do. She didn't wait for me to provide instructions, but instead asked me clarifying questions as she was reading. TS1 proceeded to talk her answers through all the pre-listening and post-listening questions, even while she was writing some responses. TS1 was keen to discuss her responses to the music with me in person, rather than writing them down, and said she would have preferred discussion to writing things down.

TS2 read through the instructions from beginning to end, so she would know how everything fitted into a big picture. TS2 was very keen to be helpful and asked me a few times if she was doing the right thing, or thinking on the correct wavelength about what she was doing, and how to answer part 1 about her 'insider knowledge' or lack thereof. TS2 also asked me if she could 'google' Barbara Heller to get more information to answer the questions and I said no. TS2 gave long answers: the actual test time seemed to take a long time compared to my own experience or TS1.

TS3 after reading the title on the questionnaire, said that he did not speak German, but TS3 made no other verbal comments regarding the music prior to listening. Immediately after listening to the music, TS3 began to verbalise his responses to the music as a whole, saying that he "really liked the music, that even though it was sectional, it was seamless" and he really wanted to talk about the music, but I

directed him to the response sheet before any of my remarks could influence him too much, adding that I too think it is a really amazing piece of music and I like it very much too.”

How much did they write?

TS1 wrote furiously during the actual listening test time and wrote answers to all the questions prior and post-listening except on one page entirely which might have been due to it being accidentally turned over, since she made no remark about not answering those questions. I would have expected her to make those remarks since she verbalised her responses to every other question except the actual listening.

TS2 wrote the whole time, she was quite dedicated, however during the listening there were times when she stopped writing and just listened.

TS3 wrote constantly during the whole of the music, and answered all the questions

Did they underline anything in the instructions?

TS1 underlined my phrase in the initial instructions explaining what to write about while listening, namely “the quality of the sounds, or your own ideas and thoughts about the sound of the music.”

TS3 underlined the phrase “about yourself or the music”

Clarification of types of responses required

TS1 see above underlining comment

TS2 asked me to explain what I meant by quality of the sound, as she thought it might mean the audio quality of the recording

TS3 see above underlining comments.

Clarification of moving onto the next observation

TS1 clarified that if she ran out of time to write down everything about one event then she should just to move onto the next observation without completing the existing observation.

TS3 observed that he would most likely have a stream of reactions to the music as it played, so how could he write everything down. I also clarified that if he ran out of time to write down everything about one event then just to move onto the next observation without completing the existing observation.

Clarification of post-listening questions

TS1: Participants are requested to make notes, on the form provided, about how the music they have just heard “makes sense” to them. This caused quite a lot of confusion, and feedback from TS1. TS1 asked me “what does making sense actually mean?” She was truly puzzled about how to answer the question. I found it hard, on the spot, to explain this term I had carefully chosen to be open ended, to allow any type of cognitive or sensory response, without providing examples, which then might be perceived as ‘correct’ answers. I was not able to clarify for her...In discussion, she said she would have found ‘meaning’ an easier term to understand than sense-making. Ultimately TS1 set and answered her own question instead of sense-making as “What are your feelings about this music?”

TS2 I offered to discuss the answers to the questions immediately after listening but TS2 said it would be easier to write down answers. TS2 underlined two words in the Q1 post-listening: “ideas” and “communicated”; Q3 How “does”; Q5. What “gives rise to your thoughts” “whole experience” “this experience of listening to avant-garde music.”

TS3 asked a clarification question about the question that refers to “this experience of avant-garde music” to check I meant this particular experience of listening to this piece of music” to which I answered yes, I meant this particular piece of music.

I.2 Coding Qualitative Listening Observations into Fuzzified Data

Quantising the time points for the visual representations

WS results My own results had been quantised at 5 seconds, because even with rounding down the initial time-points to the nearest 5 seconds, there was still only a five second interval between observations.

TS1 results The minimum time between her actual responses was 9 seconds. Yet following procedure for rounding down initial observations to the next 5 second time point, and then taking the smallest interval between time points, which was 10 seconds, meant that although I could see in about 5 of her qualitative listening observations that she had perceived quite similar things to myself at very similar time points, yet if I rounded down to 10 second quantising, there would be a lateral left shift of 5 seconds for about 5 similar observations.

However, I resolved to keep to my original method as set out about quantising, and see what the resulting visual representations would look like. In terms of my method, my rationale is as follows:

1. Keep to the method as set out, as I would expect other researchers to do.
2. Despite the differences in quantising, there are still about 3 time points that coincide between TS1 and my own, so it will be interesting to discover the relationships between my own and her observations at those time points.
3. I anticipate that the actual qualitative details of TS1's responses will vary from mine in many respects, resulting in different attribute and feature set distributions, so the resulting visual representations could look very different from mine.
4. I observe that TS1's responses are much fewer than mine overall, frequently with much greater time intervals between observations throughout, so again the resulting visual representations could look very different from mine.

TS2 taking into account the previously noted problems with cueing, noting that she had observed a time point for when the music had stopped as 10 seconds after the

actual end of the audio as measured by the duration of the audio file, I have moved the time points for all her observations back by 10 seconds. Recalling the process of rounding down each time point to the nearest 5 seconds, then taking the extra 10 seconds cueing latency meant that TS2 an event which identifies as a silence at 13'20" same as other listeners, but does not identify that the music has stopped until 13'25", but even then is not certain that the music has ended until I informed her at 13'30". Because of the problems of identifying the end of the music, without proper performance cues, I decided to make the silence observation at 13'20" the final observation for this music.

TS3 results quantised at 10". Most significantly, until coding his responses I did not realise that he verbalised that the music had ended, but did not write this down, nor noted the time point this occurred. Because it had not occurred to me that this would happen, so this means it is not possible from his observations to tell what latency might have occurred due to the start of the timing mechanism compared to the music. Because it is impossible to tell his observed time point, and in line with my policy of rounding down during quantising, I will mark a final sound event at this time point as 13'20".

I.3 Abductive hypotheses about how the music made sense

WS:

I have included my own results here even though not part of the evaluation *per se*, because the final part of this discussion does have some comparative visual representations from my own listening as well.

Potential Idea 1: Implications of the Title and other information prior to listening

There were no implications from the title before or after listening as it is in German, a language with which I am not familiar. I have no idea to what the title refers. I will be listening to this music without much guidance from the composer, or publisher.

Potential Idea 2: Immediate Impressions after listening

Immediately after listening, only two clearly related events stood out in my mind, both single notes which fade away to silence. There was a distinct possibility that

the music was sectional and that some sections never really got off the ground for some reason that was not really clear in the music itself.

All the immediate thoughts about this music were focussed on technical aspects, such as the continual variation of events, even though there was much self-referencing to other parts of the music. Textures varied widely, Register also varied a lot as did Tempo. There was much variation with most events being different in some way.

A significant thing about this music is the speed at which new events and variations of events occurred. The variations occurred in diverse ways. Some features emerged or disappeared out of the music while other features continued. Sometimes a specific type of sound event would be repeated but varied in one attribute. In fact, it became clear that continuous variation was an important aspect of the composition.

Potential Idea 3: Logical Conclusions from Visual Analysis

Immediately after listening, only two clearly related events stood out in my mind, both single notes which fade away to silence. However, these events are not identified as structural markers reinforced by relation to any other aspect of the unfolding of the music in the Time Domain, nor in relation to any other Events, beyond marking the end of their individual sections.

Analytically, the music is segmented into seven sections by the several clear Silence Events which occur at irregular times. As detailed previously, there are some visible and logical structural relationships between some of those Sections. Segmenting the work into sections shows that sections do not repeat material directly, even if there is embedded logical structural similarity.

An Abductive Interpretation: The Idea that Makes Sense of this Music

This was based on my own analysis of my own qualitative listening observations.

Immediately after listening, only two clearly related events stood out in my mind, both single notes which fade away to silence. However, these events are not identified as structural markers reinforced by relation to any other aspect of the

unfolding of the music in the Time Domain, nor in relation to any other Events, beyond marking the end of their individual sections.

The key thing that strikes me about this music is its minimalism with respect to any conventional concepts in music. For example, there are melodic fragments of one or two notes, sometimes repeated, rather than complete phrases. The music itself is built on the repetition of materials, but with variation. Primarily, the idea seems to be the continual variation of Texture, through a broad range of possibilities. When particular Textures are repeated, the repetition is also accompanied by changes in Register, Tempo or Amplitude. Many times, there is an element of uncertainty about specific Textures as events emerge over time to form separate 'voices' then recede into the background. There are groups of directly repeating events, such as Pedal Tones, or Alternating Chords, but what becomes apparent through the analysis is that the duration of groups is variable.

This, in itself, indicates that the work is very much about continual variation within limited possibilities imposed by the solo piano being played in a conventional manner. The variation in this music arises through motivic and textural differences, within the framework of conventional tempos and various conventional means of unfolding the 'voices' in the music such as arpeggiations, multi-note chords or melodic notes. What is unusual about this music is that it pushed all these conventional attributes to extremes. This, then, is the main idea behind this music. A play of convention to see how far various conventional features of music can be extended individually and in combination before they collapse.

TS1

Potential Idea 1: Implications of the Title and other information prior to listening

The title, being in German language, gave her very little information. It did affect her expectations of what she was about to hear, for she thought it might have something to do with Beethoven because of the German language title, and a movie she had seen previously about Beethoven.

Potential Idea 2: Immediate Impressions after listening

TS1 observed that the title of the music was misleading,

Immediately after listening TS1 identified that Amplitude seemed important, and she admired the playing, because the music seemed to be quite difficult technically. TS1 also identified that she had more of an emotional response to the music because the music itself was obscure and thus annoying. Particularly, she wrote that when she couldn't sing along, the music had no hope of making any sense to her. Despite this, TS1 identified the music as being atmospheric enough to suggest to her that it might be film music, with particular suggestions of horror movies, or French films, or time lapse photography or images of water.

Potential Idea 3: Logical Conclusions from Visual Analysis

The visual representations of the listener's qualitative listening observations have not been analysed by the test subject, but have been analysed by me.

The visual analysis shows that most responses by this listener were cognitive-ideational, rather than technical. However, despite the non-musical descriptors, TS1 identified 33 distinct sound events, many of which had at least one technical descriptor.

What the analysis of the visual representations suggests is that the music was composed on the basis of continual variation, because all attributes were treated equally, and there was no clear time structure based on any conventional form. However, the relatively high proportion of Multi-featured events in Texture indicates that Textures did not easily fall into readily identifiable categories, which implies that the composer is experimenting with the conventions of Texture. The high number of Emergent Feature Time Points suggests that the precise timing of the boundaries of many sound events are uncertain, which supports the idea of continual variation.

On a more subtle level, all the Silence events in this experience of the music occur in the second half of the music and have additional attributes. Also the content of the other sound events became more difficult to identify completely in technical terms,

indeed to the point that complex events and technical descriptions rarely occurred in the final quarter of the music.

These results together imply that clarity regarding the exact nature and boundaries of sound events diminished as the music unfolded. While the association of all Silence Events with other attributes infers that Silence itself brought no clarity to the interpretation of the music.

An Abductive Interpretation: The Idea that Makes Sense of this Music

This idea has been adduced by WS from my analysis of the visual representations in conjunction with the reported ideas immediately before and after listening.

In summary, the evidence from this listener is that there is no logical progression or continuation of events in the music and that most events contained some uncertainty. Thus the abductive idea that makes sense of this experience of listening is that the music was designed to be atmospheric, because it changed continuously and unpredictably, and would only make sense in conjunction with visual images with an unpredictable narrative.

TS2

Potential Idea 1: Implications of the Title and other information prior to listening

"I am curious! I expect a story, feminine-longing, emotive-it's all a big guess".

"I am expecting something dramatic and worthy of research and response. Something unexpected, unusual. Once again very curious. The idea that it is unfamiliar is very interesting. Not Britney"

"I use my intuition-where all my knowledge and ideas come from. I am assuming Barbara is female and so it is composed from that view point. 1984 was a great year and novel. I imagine the creativity and sound to be bold and tender."

Potential Idea 2: Immediate Impressions after listening

"The music was enjoyable for me to experience. It was linear and had story-like tempo of a play almost. Peaks and valleys for a hero. I strangely felt the transition from youth to adulthood."

Yes, the music does make sense, "it was very emotive. The composition seemed clear with intention, purposeful, well done. Barbara is talented and has an experienced approach-it was not haphazard or too surprising. The composition seemed articulate and interesting, very evocative."

"The composition made sense to me - very linear with various moments of interesting flurry." I think the composer was "...sharing human experiences, hers or anothers. Create something emotionally impactful and pleasant to experience. In concert this would be even better."

What gave rise to this in the music is "moments of sparse stillness and silence, chaos of conflicting tones and chords. The rhythms were very intentional, purposeful. It felt very considered and that the composition aimed to be an emotional landscape."

Potential Idea 3: Logical Conclusions from Visual Analysis

The visual representations of the listener's qualitative listening observations have not been analysed by the test subject, but have been analysed by me.

The visual analysis shows that most responses by this listener were cognitive-ideational, rather than technical. The music stimulated 50% free range thoughts, although 1 in 3 were recalls of similar materials already heard. The high number events in Reflective Events alone suggests the music is atmospheric in character.

However, despite the non-musical descriptors, TS2 identified 25% of total sound events with at least one technical descriptor. Most technical events are documented for Texture therefore this attribute is important. There is more variation in texture in final part of music but returns to sparse texture of opening, and as well the pattern of Reflective Events also breaks down at the end, showing that the end is quite different than the preceding materials.

However, there was no reinforcement of sections by multiple attributes or features, as those three sections which could be identified by silences grew proportionally shorter by the end of the music, as did the five sections identified by the occurrence of any technical attribute implies continual variation as the sections are not clearly marked by simultaneous occurrences.

In fact, different attributes occur at different times, such as Texture pairs stand out at opening and 4'10", Amplitude at 7'10', Tempo at 9'50" and the complex event clump at 11'20"-12'20" shows 5 different sections each quite different in nature and duration. Structurally the contents of each section was different as they each featured different technical attributes or combination thereof.

Partially Indeterminate Events all being Emergent Feature Time Points, shows a lot of uncertainty regarding time points of individual features within attributes.

Therefore, there does seem to be some structural design, but emphasis is on difference rather than similarity of sections, without clearly demarked boundaries between them, but rather the gradual emergence of new or similar materials. While breakdown of previously established structures and variation in Texture growing towards the end of the music suggests that the primary idea which informs the composition of this music was to be continuously evolving yet quite self-referential to provide an atmospheric environment for stimulating the listener's own thoughts.

An Abductive Interpretation: The Idea that Makes Sense of this Music

This idea has been adduced by WS from my analysis of the visual representations in conjunction with the reported ideas immediately before and after listening.

Overall, the idea which informs this music is sharing of human experience, the linear story of the emotional journey of "transition from youth to adulthood", because the "composition seemed clear and purposeful" with "peaks and valleys for a hero".

This is supported by the visual analysis which shows that the conclusion of the music is quite different than the preceding materials, but provokes significant recall of similar materials. Technically, and structurally the music was continuously evolving, as there were no clearly demarked sections, while different attributes and

Textural features at different times throughout the music. Thus, the emphasis is on difference, and the gradual emergence of new but similar materials.

TS3

Potential Idea 1: Implications of the Title and other information prior to listening

TS3 after reading the title on the questionnaire, said that he did not speak German. The test subject wrote that the title was unclear and did not tell him anything, and that he was not aware of having heard any other music by Barbara Heller. Thus he had no expectations of what he was about to hear.

Potential Idea 2: Immediate Impressions after listening

TS3 verbalised that he “really liked the music, that even though it was sectional, it was seamless”. He wrote that “I always like a strong opening statement as it creates clarity (to me), so I was instantly engaged. Then the subsequent sections [I am finding some words difficult to read here] ‘intoned nature section, toccata-like section, clocks-like section, etc. kept me engaged [his underlining emphasis]. What really sold the piece to me was the seamlessness effected in connecting the sections, as it allowed me to enjoy it without having to work too hard. I really like it.

Specifically: The music “absolutely makes sense as pure music, as I have no access to the title as it is not my language”

This music makes sense because of “Form, the development of material, a series or narrative of densities, succinctness of expression (e.g. opening statement, intoned chords after that, registral fragmentation of statement at end of work).”

The composer was trying to write “an engaging and well-crafted work. Beyond that I don’t know and it doesn’t matter.” TS3 thought this because the music contained “succinctness of expression and seamlessness.”

Potential Idea 3: Logical Conclusions from Visual Analysis

The visual representations of the listener’s qualitative listening observations have not been analysed by the test subject, but have been analysed by me.

The visual analysis shows that most responses by this listener included both cognitive-ideational and technical information.

The music stimulated nearly 60% Free Range Thoughts, and the same number of Recalls of Similar Materials already heard, but the other two feature sets also contained events, so the music clearly stimulated a lot of Reflective Events.

Most technical events are documented for Texture in five feature sets to cover 8 (i.e. 50% of total) sound events, therefore this attribute is important.

Similarly, Register has significant variation among the three events observed with this attribute.

Therefore, most individual sound events were of different character because of varying combinations of features, even though the number of attributes is quite small, while the high number of recalls of similar events suggests strong relationships between individual events.

The uncertainty in classification giving rise to multi-featured events was nearly all in Reflective Events, while uncertainty in identification was a factor for 30% of total events are Partially Indeterminate Events, most frequently due to uncertain time point boundaries, but also to the observation of only one attribute of a more complex sound event.

In terms of structure, different aspects of the music give different results.

There were no observed Silences except for the final sound event, thus the music is all one section. At the attribute level there seem to be four different sections, each with quite different content and duration, gradually getting shorter by the end of the music. Time structure of repeated Transition Pairs has no regularity in duration but does have three clear sections, which are gradually getting longer in duration. This implies continual variation without direct repetition until the possibilities are exhausted.

The Most Common Attribute Combination (Reflective Events and Texture) occur regularly spaced between 0'00' and 3'15", but this grouping never recurs exactly at any other time in the music. There are three similar but varied events in a time

group of 9'10 to 12'20" i.e. a fuzzily similar time interval. This suggests that there are three main sections plus a short finale section. Tempo and Reflective Events is similar breaking into small, large, small and smallest sections, but displaced by 1'50" from the Reflective Events and Texture events although with less variation between sections. These overlapping structures reinforce the idea of continual variation.

Yet by contrast, at feature set level, different attributes showed either none, two, three or four sections. While those with four sections had two equal sections at each end of the music with larger sections in between. Features of Tempo repeated the opening at the end of the music, however, Texture had completely varied contents in its two equal duration sections.

At several points in the music, the time interval of 1'40", or its double 3'20", stands out clearly as the time interval between very similar observations in one attribute, or the distance from either end of the music for sound events in another, yet is not reinforced in any clear sectional way by repetition of attribute or feature combinations. This suggests that the music has indeed been designed within blocks of time, within which different attributes and features are manipulated, without the music being clearly sectional.

These small level structures reinforce the idea of limits self-imposed by the composer, yet this time in the time domain.

An Abductive Interpretation: The Idea that Makes Sense of this Music

This idea has been adduced by WS from my analysis of the visual representations in conjunction with the reported ideas immediately before and after listening.

Although this music is described by three technical attributes Register, Texture and Tempo and each attribute contains only a few sound events, they are spread across as many feature sets. Texture is the attribute containing 50% of total sound events categorised into five feature sets. Therefore, most individual sound events were of different character because of varying combinations of features while the high number (56% of total events) of Recalls of Similar Events suggests strong relationships between individual events.

Similarly, the time structures vary for different sectional markers both at attribute and feature set level, with a notable absence of Silence Events. The time structure of technical attributes shows that each of the four sections has different content, while each is noticeably shorter in duration than the previous section. While the time structure of repeated Transition Pairs is completely the opposite, so that the opening events become dissipated by the end of the music. Together, these overlapping structures reinforce the idea of continual variation without direct repetition until the possibilities in the small collection of attributes are exhausted. However, the particular time interval 1'40" recurs in several of the visual representations which reinforces the idea of limits self-imposed by the composer, yet this time in the time domain. This suggests that the music has indeed been designed within blocks of time, within which different attributes and features are manipulated, without the music being clearly sectional.

Together with TS3's remarks immediately following listening that the music was identifiably sectional but a seamless narrative of Textures, the abductive idea which makes sense of this experience is to explore the range of variations possible within a highly contained set of attributes. However, the formal design is to thoroughly explore each variation in its own small section but evolve continuously from one section to the next seamlessly by avoiding Silences and direct repetition until the possibilities in the small collection of attributes are exhausted.

I.4 Visual Representations of Participants' Listening Experience

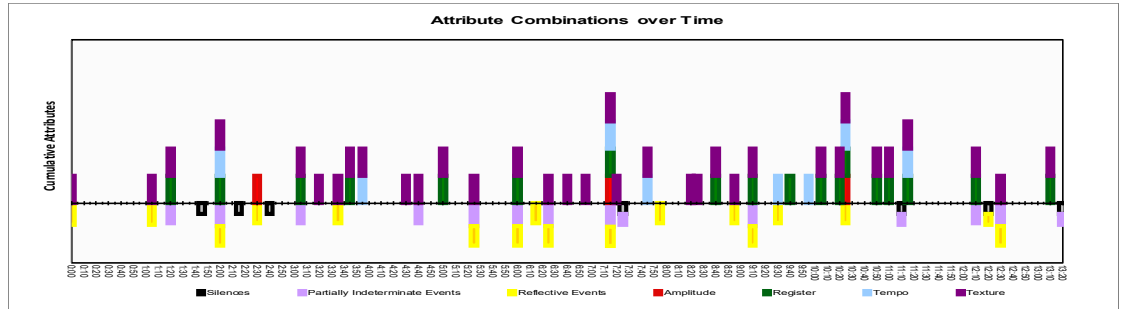


Figure I.1. WS Attribute Combinations over Time

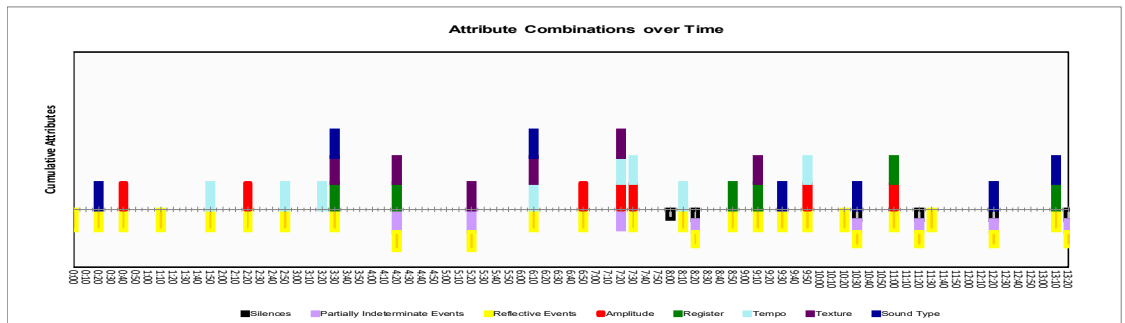


Figure I.2. TS1 Attribute Combinations over Time

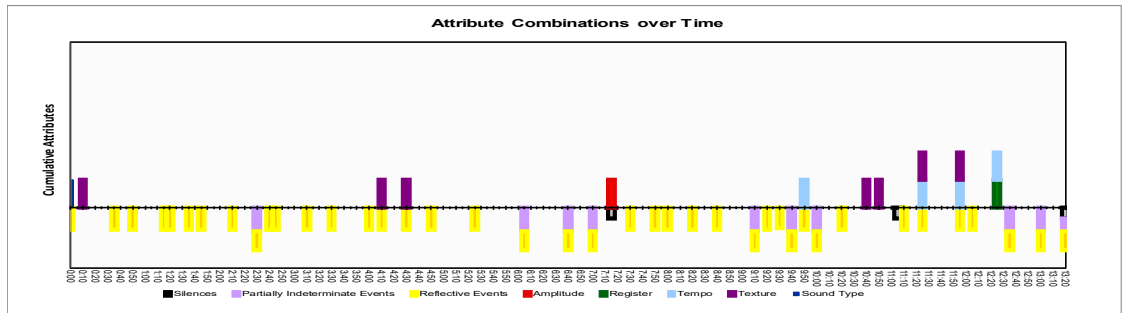


Figure I.3. TS2 Attribute Combinations over Time

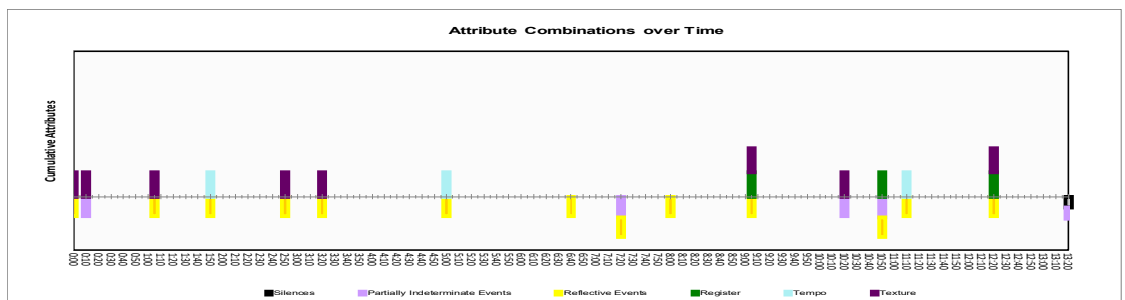


Figure I.4. TS3 Attribute Combinations over Time

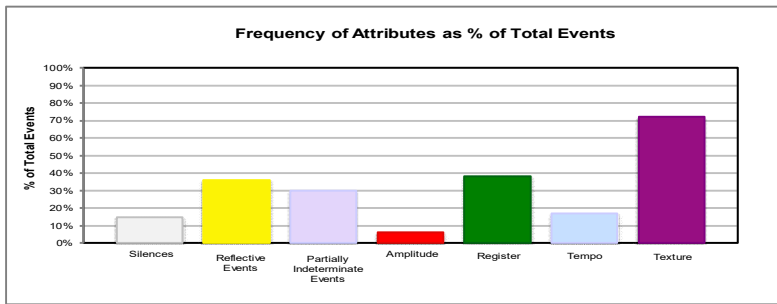


Figure I.5. WS Frequency of Attributes

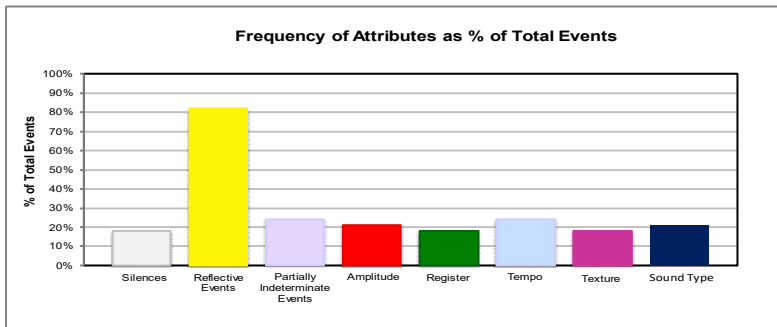


Figure I.6.TS1 Frequency of Attributes

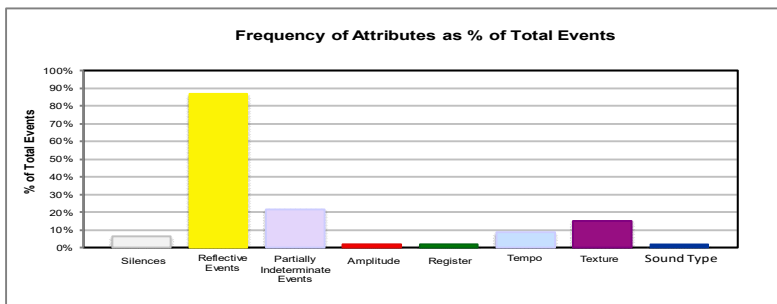


Figure I.7. TS2 Frequency of Attributes

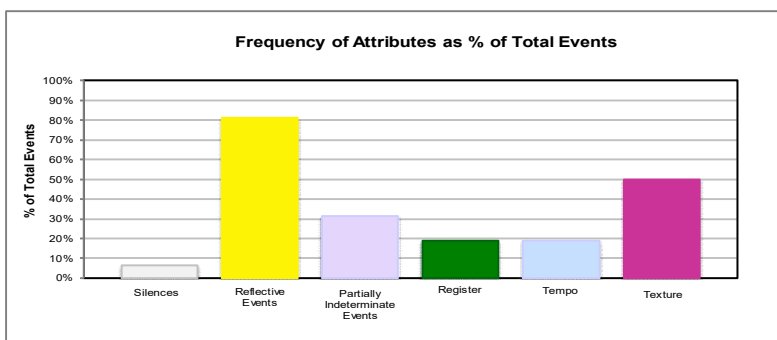


Figure I.8. TS3 Frequency of Attributes

Appendix J. Academic and Creative Research Publications during PhD Candidature

This appendix provides details of peer reviewed publications and general presentations of academic work, along with music composed and performed during my candidature as a doctoral scholar.

Peer Reviewed Academic Publications

“The Fuzziness of ‘Expression’ in Relation to Algorithmic Music”, *Proceedings of International Computer Music Conference: International Developments in ElectroAcoustics*, 11-17 August 2013, Perth, Australia, pp.327-332.

“The Promise of Fuzzy Logic in Generalised Music Composition”, *Proceedings of Second IFIP TC14, Entertainment Computing Symposium ECS 2010, World Computing Congress WCC 2010*, 20-23 September 2010, Brisbane, Australia, Nakatsu, R., Tosa, N. et al. (eds), Springer, pp.118-127.

“Toward Algorithmic Composition of Expression Using Fuzzy Logic” *Proceedings of the 2010 Conference on New Interfaces for Musical Expression (NIME 2010)*, 15-18 June 2010, Sydney, Australia, pp.319-322.

“Toward Generalised Music Analysis Using Fuzzy Logic” *Proceedings of Hawaii International Conference of Arts and Humanities*, 13-16 January 2010, Honolulu, Hawaii, pp.1956-1965.

“Listening Chairs: Personal Acoustic Space in Public Places” co-authored with telecommunications engineer Eva Cheng, *ACMC 2008: Sound: Space, Australasian Computer Music Conference 2008*, Sydney, 10-12 July 2008, pp.85-90.

Peer Reviewed Publications of Music

“Clarinet Calling”, music score for clarinet, cello and piano, *Publications by Wirripang*, 2010.

“Litany for Refugees” sampled voice digital music, *Unfenced*, Australasian Computer Music Association CD 2008.

Other Publications

"Preface" to *Ludwig van Beethoven, Streichquartett F-Dur: Erste Fassung des Streichquartetts, Opus 18 Nr 1*, Repertoire Explorer, Study Score 997, Musikproduktion Hoeflich (MPH), Munich, 2010, pp.1-6.

"Carlin" piano trio, *Rear Vision*, Melbourne Composer's League CD 2008.

Conference Presentations

"Characterising Creative Decision Making in Algorithmic Music Composition", *Construction, Deconstruction and Re-creation: The Life Cycle of Music*, ANU School of Music Post-graduate Symposium, Australian National University, Canberra, 14 November 2014.

"Composing Expression in Music: What is the Question?" *The Politics of Music: 35th Annual Conference*, Musicological Society of Australia Conference, Australian National University, Canberra, 5 December 2012.

"A Composer's Perspective on Expression in Music", *Music in Time: Approaching past, present, and future musics*, ANU School of Music Post-Graduate Symposium, Australian National University, Canberra, 25 November 2011.

"Cross Artform Collaboration as the Epitome of Practice-Led Research" *Faculty of Creative Arts Post Graduate Conference*, University of Wollongong, Wollongong, 8 September 2010.

"Connecting Musical Ideas Using Fuzzy Thinking", *Faculty of Creative Arts Post Graduate Conference*, University of Wollongong, Wollongong, 24 September 2009.

"Composition With a Foot in Each Camp" *Faculty of Creative Arts Post Graduate Conference*, University of Wollongong, Wollongong, 10 September 2008.

"Connecting Musical Ideas Using Fuzzy Thinking", *Crisis, tension, transition, transformation*, 16th Annual EMPA Symposium, University of New South Wales, Sydney, 15 October 2009.

Other Presentations

"Fuzzy IDEAS: Using Fuzzy Logic to Make Sense of Avant-Garde Music." *2016 Research Seminar Series*, School of Music, Australian National University, Canberra, 29 September 2016.

"The Fuzzy Logic of Listening" *Scholar Musician*, School of Music, Australian National University, Canberra, 1 September 2016.

"Fuzzy IDEAS: Using Fuzzy Logic to Make Sense of Western Art Music." *2015 Research Seminar Series*, School of Music, Australian National University, Canberra, 30 July 2015.

"Composing Expression in Music: What is the Question?", *2013 Research Seminar Series*, School of Music, Australian National University, Canberra, 28 February 2013.

Artists Talk "Prayer Pocket Place" in collaboration with visual artist Dr Flossie Peitsch, *Belconnen Arts Centre*, Canberra, 29 September 2012.

"The Political is Personal: The Impact of Feminism and Patriarchy" *SLEEVES & SHEETS, SOCKS & POCKETS: A Textured Studio Inquiry into Women's Work in the Illawarra*, Wollongong City Gallery, Wollongong, 6-7 May, 2011.

"Poesis and Praxis: The View of the Early Career Researcher" *Faculty of Creative Arts Lunchtime Seminar Series*, University of Wollongong, Wollongong, 18 September 2008.

Peer Reviewed Performances of Music Compositions

"steps to..?" sampled natural sounds, *60x60 Concert I, Australasian Computer Music Conference 2014*, Victoria College of the Arts, Melbourne, 9 July 2014.

"E is for Expression" computer music installation in collaboration with visual artist Dr Flossie Peitsch, *SoA Foyer Gallery, Australian National University*, Canberra, 8-19 October 2013.

"Prayer Pocket Place" sampled sounds of the art making, computer music installation in collaboration with visual artist Dr Flossie Peitsch, *Arts Lounge, Belconnen Arts Centre*, Canberra, 28 September-14 October 2012.

“Clarinet Calling” for clarinet, cello and piano, *Charisma Ensemble*, UTS Bon Marche Studio, Sydney, 10 May 2012.

“Stirring” sampled sound becomes visual music in collaboration with filmmaker Elizabeth Eastland, *Seensound Visual/Music Series*, LoopBackroom, Melbourne, 2 May 2012.

“Prayer Pocket Place” sampled sounds of the art making, computer music installation in collaboration with visual artist Dr Flossie Peitsch, touring exhibition of *Meroogal Women’s Art Prize 2011*, *Lady Denman Museum*, Nowra, 1-30 October 2011.

“Prayer Pocket Place” sampled sounds of the art making, computer music installation in collaboration with visual artist Dr Flossie Peitsch, shortlisted for *Meroogal Women’s Art Prize 2011*, *Shoalhaven City Arts Centre*, Nowra, 27 August-30 September 2011.

“Clarinet Calling” for clarinet, cello and piano, *Composers from the Illawarra*, *Charisma Ensemble*, Recital Hall West, Sydney Conservatorium of Music, Sydney, 29 August 2010.

“Music 4 Alice (Betwixt)” sonata for digital piano and computer, *Australasian Computer Music Conference 2010 Concert Series*, Australian National University, Canberra, 25 June 2010.

“Frog Music 1 (LD)” sampled natural sound, computer music presented at *Digital Jukebox*, *ACMC 2009: Australasian Computer Music Conference*, Queensland University of Technology, Brisbane, 2-4 July 2009.

“Music 4 Alice (Betwixt)” sonata for digital piano and computer, *World Electro-acoustic Listening Room*, *8th Annual New Music Festival*, California State University, Fullerton, California, USA, 18-29 March 2009.

“Clarinet Calling” for clarinet, cello and piano, *Kammer Ensemble*, Performance Space, University of Wollongong, Wollongong, 14 May 2008.

“and they timed it exactly...” sampled sounds, digital music and visual installation in collaboration with Eva Cheng, *Composing Women’s Concert, Boite World Music Cafe*, Melbourne, 18 October 2008.

“Lament for a Lost Dream” four minute digital opera, Digital Jukebox, ACMC 2008: Sound: Space. Australasian Computer Music Conference, Sydney, 10-12 July 2008.

“Litany for Refugees”, *New Electronic Music from Australia and New Zealand*, Bennington College Listening Room, Vermont, USA, 28 April-5 May 2008.

Participation in Curated Creative Projects

“Flagged for Conversation” spoken word performance, interactive website and mixed media installation in collaboration with visual artist Frances Burnham, *Pledge for Parity, Project Contemporary Art Space*, Wollongong, 2-20 March 2016

“Me, Myself, I” digitally edited photograph, *The Dinner Table Project*, online and *Wollongong Central*, curated by *Multicultural Services, Wollongong City Council*, Wollongong 6-20 January 2016

“Stirring” sampled field recording, in collaboration with filmmaker Elizabeth Eastland, *Re:Cinema, Parsons The New School for Design*, New York, 20 December 2013-31 January 2014.

“Stirring” sampled field recording, in collaboration with filmmaker Elizabeth Eastland, *Re:Cinema, International Symposium on Experimental Arts, ISEA2013*, SCA Galleries, Sydney, 28 May-14 June 2013.

“A Country Women’s Chorus (2013)” Composer in Residence with contributions from conference participants, *National Rural Women’s Conference 2013*, auspiced by *Centenary of Canberra 100*, Canberra, 18-20 February 2013.

“The Personal Politics of Prayer Pocket Place” invited presentation at *NSW Lutheran Women’s Annual Retreat*, Canberra, 10 March 2012.

“Cycles of Life” field recordings become soundscape installation in *Igniting Women’s Spirit*, Narelle Byrne Gallery, Melbourne, 5-13 March 2011.

“Waveform 0.5” in *Feedback*, in collaboration with Jessica Millman (dancer) and Toby Knyvett (lighting designer), Illawarra Performing Arts Centre, Wollongong, 8-9 September, 2010.

“Waveform” sculptured field recordings, in collaboration with visual artist Clare Wallace, *~~on the shore~~(outdoor sculpture exhibition)*, *Thirroul Seaside Festival*, NSW, 27-28 March 2010.

“Frog Music 1 (LD)” sampled natural sounds, computer music presented at *¼ Inch*, Wollongong, 22 September 2009.

“and they timed it exactly...” sampled sounds, digital music and 3D installation in collaboration with telecommunications engineer Eva Cheng, *¼ Inch Electro-acoustic Music Series*, Wollongong, 10 September 2008.

“the sea leaves ear-shells...” chamber music ensemble and sampled natural sounds, *Chronology Arts & Illawarra Music Society*, Wollongong, 27 July 2008.

“Frog Music 1 (LD)” sampled natural sound, *Aurora Festival*, Joan Sutherland Performing Arts Centre, Penrith, 18 April 2008.

“Lament for a Lost Dream” four minute digital opera, *Orpheus Remix Awards*, abc.net.au/classic/orpheus, February 2008.

