The Nature of Linguistic Short-Term Memory
and Children's Comprehension of Spoken
and Written Language

(An investigation into the fate of sentences
in connected discourse immediately following
auditory and visual presentation)

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Except where otherwise acknowledged in the text this sub-thesis represents the original research of the author.

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Secondly, I wish to thank the A.C.T. Schools Authority for allowing me access to the Narrabundah Primary School to carry out the research reported in the following pages. I 'lived' at the school for several months and during all that time was made to feel 'at home' by the headmaster, Mr J. Hamilton, and his staff. Special thanks must go to Mesdames Cummins, Faenza, Hoyle, Kennedy and Smith, whose reading groups took part in the study and who were always ready to co-operate at the expense of personal convenience. However, the people I am most indebted to are the fifty children, who willingly and enthusiastically took part in the 'games' I had prepared for them. On the one hand, I am sorry that I had to practise this kind of deception on them; on the other, I am glad that they appeared to derive satisfaction and fun from their unusual 'lessons' with me.

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I am in debt also to the two external examiners for pointing out weaknesses in the original submission. Wherever possible I have tried to deal with their comments and queries by addressing them in appropriate places in the main text or by the inclusion of additional notes at the end of each chapter. However, some weaknesses in the design of the study could not be overcome short of it being redone from the beginning. For a number of reasons this was impossible. The inherent shortcomings of the original design are acknowledged and should be taken into account when evaluating the results.

I am particularly appreciative of the consultation with Dr Olga Katchan in this respect. Her criticism and advice have made me much more aware of method and thinking in cognitive psychology.

For a number of compelling and not so compelling reasons there has been a considerable lapse of time since the original submission. While this revision is an attempt to take into accounts the comments of the external examiners it still largely reflects the 'state of the art' in the early and middle 'seventies. New developments in psychology may have changed the picture significantly. However, a discussion of some of the more recent writings (to 1981) on the role of short-term memory in natural language processing in general and reading in particular has been included.
Comprehension of natural language suffers at input rates above the normal speech range. If the same were true for very slow input, this would have important implications for certain types of readers. Slow reading rates exceeding the temporal capacity of a hypothesized short-term memory (STM) store, believed to play a central role in the processing of sentences, has been blamed for observed comprehension deficits in slow readers. A study involving several groups of slow-reading children showed that good comprehension can be achieved even if the hypothesized limits of the STM store are exceeded. The results of the study can be explained in terms of alternate models of sentence processing which (a) redefine the conventional view of a largely passive STM, strictly limited in capacity and function, into STM as a working space with considerable flexibility and semantic processing capability, or (b) models which are based on a more unitary view of memory and information processing with no need for a separate STM, or where something like a STM is retained but with a less crucial importance for language processing.

The results also indicate that theorists and practitioners in fields outside psychology should exercise caution in extrapolating findings from experimental psychology involving atypical material and settings to tasks and situations requiring natural language processing such as in the reading and comprehension of meaningful prose in everyday life.
A field trip to the Northern Territory in May 1975 at the invitation of the Commonwealth Department of Education has provided the stimulus for the investigation which is reported below.

At the time the plan was for the initial trip to be followed by a period of intensive fieldwork, the results of which were to provide the basis for the writing of a Master's thesis in linguistics. One area which the Education Department was particularly interested in having investigated was their newly instituted programme of bilingual education for Aboriginal children in the Northern Territory. This programme had received a start in selected schools shortly after the advent of the new Labor government in 1972, with its promise of greater opportunities for Australian Aborigines. The scheme envisaged instruction through an appropriate vernacular in the lower primary school, followed by English as a second language at a later stage. The introduction of English literacy was to be delayed to allow for proficiency in vernacular literacy and oral English to be developed. A detailed description of the philosophy underlying the programme and ways and means of achieving its goals can be found in Watts, McGrath & Tandy (1972). Recommendations for the maintenance and future development of the scheme were put forward by O'Grady & Hale (1974), and interim reports published by the Department of Education are also available (1973, 1974).

The May visit occupied about two weeks and included two- and three-day working sessions at three Aboriginal primary schools in Eastern Arnhem Land. In each location children were observed informally during regular lessons, and samples
of oral reading in the vernacular and in English were tape-recorded. The main interest of the Education Department in the investigation centred around the question of whether any linguistic considerations were associated with the transfer from vernacular to English literacy and the identification of potential problems. Apparently none of the schools already offering the bilingual programme had officially made the switch to English literacy.

While the objectives of the original trip, i.e., familiarization with the context in which the bilingual programme operated, a rough on-the-spot assessment of standards already achieved, the isolation of a few obvious problem areas, and the collection of some preliminary linguistic data were more or less achieved, personal reasons prevented the writer from returning to the Northern Territory for the planned second period of intensive fieldwork which would have been essential for more in-depth observation, experimentation and the testing of any tentative hypotheses that resulted from the analysis of the data already recorded. Since further fieldwork was out of the question and time was becoming valuable, it was decided to isolate and concentrate on a phenomenon which, while not tied to the context of bilingual education or any particular Australian language, had wider, perhaps universal, implications and which could be readily studied in a population of schoolchildren in Canberra, A.C.T.

While the usual type of errors found in the oral reading of English-speaking children (e.g. Webster, 1968) also occurred among the Aboriginal children, the most striking weakness observed for reading in the vernacular was the astonishingly slow oral reading rate. This applied to 'new', i.e., previously unseen material as well as 'old', i.e., previously read, primer texts. The latter condition in which children had to re-read primers several times was indeed a fairly common one and was due to the slow progress being made in the production of almost any kind of vernacular literature. Even so, children classified as average readers, who had
received reading instruction for periods of at least a year to more than two years, achieved extremely slow reading speeds for oral reading. Silent reading was not an issue, as apparently the children had not progressed to that stage. Average reading rates of 0.4 syllables per second were recorded for previously unseen material and about double that rate for well-known texts. These rates represented average achievement as judged by the classroom teachers of the children involved.

The reason for adopting the syllable, rather than the more commonly used word as the unit for measuring reading rate has been the difference in average word length between English and the two Australian languages concerned. While one-syllable words abound in English, particularly in primers for beginning readers, mono- and disyllabic words are either absent or fairly rare in Australian languages generally. With the printed word, here functionally defined as the unit bounded by blank spaces on either side, we find that in the two Australian languages the average word length for the early primers is approximately $3\frac{1}{2}$ and 3 syllables respectively while for a story constructed to test English-speaking children in Canberra word length averaged less than $1\frac{1}{2}$ syllables (see Appendix A). The alternative of using the morpheme as the basic unit of measurement was also rejected.

Returning to the problem of an exceedingly slow reading rate, its significance must be seen in the light of statements made about the handicaps suffered by those who are afflicted by it. Apart from the obvious one that a reader must invest more time to cover a given amount of reading matter when he reads more slowly, slow reading speeds have also been linked with impaired comprehension of what is being read. Given that most readers can and do vary their speed according to the type of reading material and the purpose they are reading for, the fluent reader is said to have the edge in comprehension over a basically slow reader (Schonell, 1948, 1961).
Traditionally, reading comprehension has been measured by the subject reading a prose passage followed by a battery of comprehension questions of one type or another. However, even if such tests did show up some kind of comprehension deficit in very slow readers, they could not give any indication of exactly when and why a loss in comprehension occurred. It has only been recently with the appearance of multi-store theories of human memory in cognitive psychology (Miller, 1956; Broadbent, 1957) that it became possible for people working in the reading field to sheet home the blame to factors operating in human memory. Loss of comprehension in very slow readers could now be attributed to the limited capacity of one of the memory stores commonly referred to as Short Term Memory, or STM. Very simply put, this view sees the very slow reader in perpetual danger of exceeding the temporal limits of his STM and not being able to remember the beginning of a sentence by the time he reaches the end; thus failing to put it all together for good overall comprehension. The following quotations illustrate this point of view:

(Reading a word at a time) will involve the reader in so much delay that his short-term memory will be overloaded and he will lose the sense of what he is reading.

(Smith, 1973:89)

'But if he (the poor reader) goes slowly, he may well be unable to make sense at all of what he reads.'

(Mattingly, 1972:145)

*If he takes too long to read a given word, the content of the immediately preceding words will have been lost from PM (Primary Memory) and comprehension will be prevented.*

(Gough, 1972:354)

In addition to explaining the comprehension difficulties of slow readers the notion of a limited short-term memory store has been taken up and implicated in fields which are apparently only peripherally related; e.g., language acquisition (Fodor, Bever & Garrett, 1974); information theory (Weltner, 1973); mathematical and psycholinguistics (Miller & Chomsky, 1963); interviewing (Circourel, 1974);
reading-ease formulae (McLaughlin, 1974); learning theory (Hilgard & Bower, 1975) and second language teaching (Stevick, 1978). The general view of the absolute necessity for some kind of short-term memory store has been stated forcefully by Olson:

There are obvious ways in which the ability to produce or to understand sentences depends upon the ability to remember temporarily certain constituents while processing others. In fact, without temporary storage there would seem to be no way we could speak or understand the speech of others.

(Olson, 1973:46).

None of the writers quoted above make any reference to specific characteristics of short-term memory such as its exact capacity, primary mode of representation, the nature of its control processes, and its precise role in the processing of natural language. It is precisely this lack of detailed understanding of the role of STM in the processing of natural language which makes the claims of the various writers difficult to evaluate. Empirical validation of these claims would have important implications for the selection of methods and materials in the teaching of reading. For example, at least for pupils who have been identified as 'slow readers', stories might contain only sentences which have been deliberately kept short; or, on a more general level, one could argue that satisfactory comprehension will depend on a certain minimum rate of reading right from the beginning and that this rate should be measured in terms of sentences per unit of time.

The questions which have to be asked, then, and hopefully answered are these:

1. What is the general validity of a distinction between short-term memory and long-term memory in a multi-store model of memory?

2. Given the validity of such a division, what is its relevance to natural language processing and,
in particular, what are the capacity and function of the STM component in reading?

Chapter II will trace the history of research into human memory and summarize the evidence for the existence of a multi-store system of memory. The relevance of a short-term versus long-term store within such a system to the processing of a natural language unit, such as the sentence, will be discussed.
NOTES - CHAPTER I

1. Angurugu on Groote Eylandt, Galwinku on Elcho Island, and Milingimbi on the mainland.

2. Anindilyaugwa (Groote) and Gupapuyngu (Galiwinku, Milingimbi); children in school before the introduction of bilingual education continued with monolingual instruction in English.

3. Personal communication - W. McGrath, Principal Adviser, Bilingual Education, Northern Territory Education Division.

4. 'Unseen material' refers to a story not previously read but containing vocabulary and grammatical structures already encountered in the reading programme.

5. Teachers indicated that there were hardly any children that read much above the norm but that there were several with little or no achievement.

6. There are difficulties associated with comparing number and status of morphemes across markedly different languages. In addition, there are no comparable figures expressed in morphemes available for speech and/or articulation rates, which are normally expressed in number of syllables per second (cf. Goldan-Eisler, 1968). Since there appears to be a widely acknowledged relationship of some sort or another between speaking and reading; see Sticht (1974) for a major summary of research into this relationship; it was considered desirable to have a unit of measurement that can be readily applied to both spoken and written language and which affords a fair degree of neutrality for across-language comparisons.

7. See Chapter II for an elaboration of the multi-store model of memory as defined in psychology.

8. Also referred to in the literature as 'immediate', 'primary' or 'working' memory. While these terms do appear in the literature as if they were interchangeable, some writers have drawn a distinction between the classical view of STM as a largely passive temporary storage buffer and that of a 'working memory' - an active component in the human processing system, having both storage and processing functions (cf. Daneman & Carpenter, 1980). The idea of 'working memory' will be taken up again in Chapter V.
CHAPTER II

THE PERCEIVED NATURE OF SHORT-TERM MEMORY

Scientific interest in the nature of human memory goes back to at least Aristotle (Tulving & Madigan, 1970). However, according to these writers no dramatic new insights have been gained since that period some 2,300 years ago; this in spite of the innumerable attempts that have been directed at unravelling the mysteries of the human memory system during the last hundred years or so.

This latter period is of interest because it saw the demise of a school of thought in psychology, often referred to as rationalism, and the rise of another tradition, that of empiricism. A similar development can be observed in the field of linguistics where the rationalist tradition espoused by Wilhelm von Humboldt early in the eighteenth century was supplanted by a viewpoint that wanted to see the study of language become more like an exact science, stripped of such mentalistic notions as innate properties of the human mind and investigative techniques involving the use of introspection and intuition.1

In linguistics the influence of the empiricist tradition diminished with the arrival of Chomsky in the 1950s2, but not so in psychology where empiricism appears to have retained a central influence.2a

A look at the history of research into human memory can help us to understand why present-day pronouncements on the role of human memory in language processing are based, apparently without serious misgivings on the part of their authors, on findings gleaned by psychologists from studies which had nothing or very little to do with natural language processing.3
That this was not always the case can be seen in the works of Wundt, Bühler, Binet and others who at the turn of the century were very much concerned with the comprehension of and memory for sentences (Blumenthal, 1970).

Wundt's view of the role and function of certain aspects of short-term memory (he uses the terms 'consciousness' and 'attention span') is stated in the following excerpts from Blumenthal's translation of a section from Wundt's Die Sprache:

The sentence is not an image running with precision through consciousness where each single word or single sound appears only momentarily while the preceding and following elements are lost from consciousness. Rather, it stands as a whole at the cognitive level while it is being spoken. If this should ever not be the case, we would irrevocably lose the thread of speech. . . . The listener must recombine sound sequences into the 'Gesamtvorstellung' (total representation) quite rapidly or he is lost. . . . The attentive listener's retention of exact wording may be poor although he understood perfectly.

(Blumenthal, 1970:20-31)

This last statement, of course, foreshadows a distinction between two types of memory, i.e., short-term memory, equal to Wundt's 'consciousness', and long-term memory from which the content of individual sentences is recalled more often than not in gist form rather than verbatim. This distinction in the human memory system between two or more component stores has been articulated much more clearly in recent years as the multi-store models of memory have become the dominant paradigm for memory research within psychology - from where the notion of several types of memory found its way in oversimplified form, and possibly misinterpreted and misapplied, into other subject fields.4 One of Wundt's students, Victor Henri, in collaboration with his countryman Binet in 1894 conducted a number of experimental studies in the reproduction of sentences. Other studies using the sentence as the basic unit of investigation were carried out elsewhere (Blumenthal, 1970). Unfortunately, this promising beginning did not maintain its momentum and sentence
studies made way for word association studies which apparently proved more amenable to experimentation. This unhappy trend for psycholinguistic inquiry reached what seemed its ultimate conclusion when the nonsense syllable was introduced by Ebbinghaus towards the end of last century. He made this innovation specifically to exclude natural language influences from his research findings; and for some time it became the prevailing experimental unit. Since then experimenters have gone further in their desire to escape the apparently difficult to control power of natural language in experimental settings. In order to study so-called 'pure' memory, uncontaminated by natural language influences, they have invented constructs such as consonant trigrams; e.g., BCD, ZDX etc., which make conclusions drawn from this kind of experimentation appear less relevant to the understanding of human language abilities than ever before.

Psychologists, then, seem to have been resorting to a small assortment of very much atypical material - purged of the meaning, relevance and motivation associated with language use in real life.

Outside psychology laboratories there are no obvious situations in which people are asked to perform tasks such as memorizing a string of nonsense syllables to be recalled after counting backwards in threes for a specified period of time. For their troubles, subjects, often first year university students, are usually paid a small amount of money or given some credit towards fulfilment of course requirements in an introductory psychology unit. The relevance of these studies for our understanding of reading depends largely on an assumption that has not been confirmed empirically; and that is that memory can be understood independently of meaning.

The question of how people do come to remember a vast amount of information but seem to be unable to retain very much of it in consciousness at any given time led William
James in 1890 to postulate two different types of memory which he referred to as 'primary' and 'secondary' memory (reported in Norman, 1976). James apparently defined his terms introspectively, equating primary memory with an event that had never left consciousness and hence presenting a faithful mirror of something just perceived. Secondary memory, on the other hand was said to contain events of the past, being full of gaps and distortions in the representations it contained.

James's notions were taken up again, and subsequently further developed, at about the time Miller (1956) wrote his article on the magical number seven. Broadbent (1957) described the rediscovered primary memory (now called short-term memory) as a temporary store with a maximum time of storage in the order of seconds. Later Waugh and Norman (1965) and Atkinson and Shiffrin (1968) followed with elaborate descriptions and interpretations of multi-store models of memory with particular attention to the short-term component of the system.

The literature on multi-store models, and particular reports of experiments using one or another of these models as theoretical base, is quite extensive. A thorough review would involve several thousand sources, over ninety per cent of which Tulvig and Madigan (1970:44) have either termed 'utterly inconsequential' or 'run of the mill'.

It would seem appropriate at this point to summarize the main arguments which have been put forward in support of multi-store models of memory; in particular the postulated dichotomy of a short- and a long-term store and the hypothesized functions and parameters of these stores.

Distinctions between short-term memory (STM) and long-term memory (LTM) are usually made on both logical and empirical grounds (Klatzky, 1975). One line of evidence cited comes from the study of patients with damage to the hippocampal region of the brain. Milner (1970) describes patients who
were unable to recall events which took place after they had received their injury but were able to remember events which had occurred prior to that point. Similarly, a person with what has become known as 'Milner's Syndrome' can remember information immediately after it has been presented and can retain this information as long as he is permitted to repeat it to himself over and over. However, as soon as this rehearsal process is interrupted the patient can no longer retain the information for subsequent recall. This phenomenon is interpreted as the patient having an undamaged LTM as well as STM but that somehow the ability of the patient to transfer information from STM to LTM has been lost as the result of the particular damage suffered by his brain.

A second line of evidence in support of a dichotomy in the human memory system comes out of the area of memory experimentation itself. Time and time again researchers have found that if subjects are given a long list of items (e.g., syllables, digits, words) to remember, the results of their attempts at recall can be plotted in the form of a typical U-shaped curve (Klatzky, 1975). Figure I is an adaptation of such an idealized curve from Atkinson and Shiffrin (1968).

(Refer to Fig. 1 overleaf)
The interpretation of the curve is as follows. The somewhat better recall of items at the beginning of the list (the so-called 'primary effect') compared to those following in the middle position is explained as the result of recall from LTM. At the beginning of the task the subject's LTM is believed to be uncluttered and ready to receive newly incoming items. Conscious rehearsal then enhances the prospect of leaving a strong enough trace in LTM for the item to be recalled with greater probability later on. However, as more and more items from the experimenter's list are inexorably flowing into the subject's STM, the limited capacity of his STM to hold and rehearse items is soon exceeded and most of the middle-order items are 'lost'; i.e., they are not effectively transferred to LTM, making a subsequent recall rather unlikely.
The explanation of the recency effect is an extension of this argument whereby the last few items in the list are best recalled in an immediate recall task because they represent the current content of STM free of further competition from any more incoming items. Usually, subjects begin their recall with the last few items presented, and this adds support to the argument. Further support for this thesis comes from the fact that the primacy and recency effects can be experimentally manipulated. If, for example, subjects are not allowed to begin recall immediately but are given a distractor task (e.g., counting backwards by 3s for a specified time) like in the widely adopted Peterson and Peterson paradigm (1959), the recency effect disappears. The irrelevant distractor task is said to have taken over the STM space previously occupied by the last few items in the list to be remembered. Similarly, the recency effect can be reduced by increasing the presentation rate of items, thus reducing the time available for occupation of STM space and hence the opportunity for rehearsal and effective transfer into the LTM store.

The experimentally induced recency effect has a correlate in everyday life where a listener is more likely to recall verbatim the last sentence he has heard rather than any of the preceding ones - of which he is usually only able to recall the 'gist' (Fillenbaum, 1973).

In addition, errors in recall performances during certain experimental tasks have been quoted in support of a duplex memory system. In STM recall paradigms, errors often point to acoustic confusion; e.g., a 'B' is recalled as a 'V' even if the items had been presented visually. On the other hand, in long-term memory tasks errors in recall are generally semantic in nature; e.g., 'labour' is more likely to be recalled as 'work' than, say, 'lather' (Klatzky, 1975).

Turning now to the distinguishing features of the various multi-store models of memory we have a useful summary in
the chart provided by Craik and Lockhart (1972)

<table>
<thead>
<tr>
<th>Feature</th>
<th>Sensory Register</th>
<th>STM</th>
<th>LTM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entry of Information</td>
<td>Pre-attentive</td>
<td>Requires Attention</td>
<td>Rehearsal</td>
</tr>
<tr>
<td>Maintenance of Information</td>
<td>Not possible</td>
<td>Continued Attention,</td>
<td>Repetition, Organization</td>
</tr>
<tr>
<td>Format of Information</td>
<td>Literal Copy of Input</td>
<td>Phonemic, probably visual, possibly semantic</td>
<td>Largely semantic, some auditory and visual traces</td>
</tr>
<tr>
<td>Capacity</td>
<td>Large</td>
<td>Small</td>
<td>No known limit</td>
</tr>
<tr>
<td>Information Loss</td>
<td>Decay</td>
<td>Displacement, Possibly Decay</td>
<td>Loss of accessibility or discriminability through interference</td>
</tr>
<tr>
<td>Trace Duration</td>
<td>½ to 2 seconds</td>
<td>Up to 30 seconds</td>
<td>Minutes to Years</td>
</tr>
<tr>
<td>Retrieval</td>
<td>Read-out</td>
<td>Probably automatic, items in consciousness, temporal/phonemic cues</td>
<td>Retrieval cues, possibly search process</td>
</tr>
</tbody>
</table>

Commonly accepted differences between three memory stores in multi-store memory models

(After Craik and Lockhart, 1972)

In considering the relevance of the various features and parameters assigned to STM (see Table I above) to the processing and understanding of whole sentences or even larger units of natural language discourse, it must be kept in mind that this basic picture of the STM store has been derived through experimentation with subjects confronted in atypical situations with atypical tasks involving atypical material.
The features of STM which are of particular interest to the problem under investigation are those underlined in Table I. The sum total of experimental results obtained in these areas then depict the STM area as having a small capacity, losing items through either overcrowding or having to hold items beyond '30 seconds'. Continual rehearsal, however, will maintain items indefinitely while at the same time assisting in laying down a strong trace in long-term memory.

Another control process which helps the STM store cope with incoming information, but not mentioned by Craik and Lockhart, is commonly referred to as 'chunking'. As Miller (1956) pointed out, it is easier to memorize whole words than the individual letters they are written with and that a whole sentence is better recalled than an equal number of unrelated words in a list. Miller quotes in detail the experiment conducted by Sydney Smith in 1954 which nicely illustrates the process of 'chunking', but unfortunately the material used (strings of binary digits) does not illustrate how the process works with natural language units beyond the word. To this writer's knowledge there has been nobody willing or able to demonstrate a psychologically, and not merely a linguistically valid 'chunking' process and the size of the units involved in such a process.

Simon (1974) made an attempt to estimate the size of a chunk using syllables, words, phrases and sentences as input to be recalled. Although he did use units beyond the word, the phrases and sentences employed must be regarded as highly atypical in that they consisted of well-known fixed expressions such as 'Milky Way' and 'To be or not to be, that is the question'. Using only himself as subject, Simon found that with single words Miller's (1956) magical number of 7 was about right, but that with phrases and sentences, even though they were highly familiar to him, he could only recall four and three respectively. Broadbent (1974) also finds no real magic in Miller's seven chunks and would prefer to see the number reduced to no more than three.
Wanner (1974), who perhaps has gone into more detail than anyone else about remembering, forgetting and understanding sentences in his monograph of the same title, professes himself ignorant of the size of the chunk for connected discourse and whether such chunk corresponds to units held in STM (referred to by him as 'preliminary' store).

It must be noted here, too, that before any attempt is made to specify the nature and size of a psychologically real chunk in terms of linguistically describable units such as phrase, clause, sentence, or subject, object, etc., it must be realized that within any such category anything from single words over a minimum combination of words to something which, theoretically at least, approaches infinity; i.e., any phrase, clause, sentence and units beyond have no fixed theoretical limit as far as length is concerned.

The second major control process which is generally acknowledged as operating within STM is rehearsal. By repeating something over and over, either overtly or covertly, the information is retained in STM for immediate recall or transfer to LTM. In the psychological experiments where rehearsal is typically observed, or even induced by the experimenter, the material presented is usually of the type already discussed and the subjects are quite aware that they are required to recall the material verbatim and possibly even in the same order as it was originally presented to them. Similar tasks may occur in real life and nearly everybody would be familiar with a situation that requires one to memorize, for example, a telephone number or a set of detailed instructions; tasks in which accuracy, i.e., verbatim and correct serial order recall are crucial. However, in the normal event of listening to a speaker or reading a piece of prose one would intuitively reject the proposition that the listener/reader is actively rehearsing all or part of what he is hearing or reading. Admittedly, when reading material of some complexity, the reader may backtrack or take several passes over the same sequence of printed language in order to get at the meaning
of what he is reading. But this behaviour appears to be in the nature of problem solving and not comparable to the standard rehearsal strategies used by mature subjects in typical memory experiments.8

With the nature and function of the two main control processes operating in STM either in doubt (rehearsal) or at least unclear (chunking) as far as the processing of natural language discourse is concerned, the other STM feature which is of direct importance to us here is the temporal parameter of the store. The question of how long items can reside in the store without rehearsal and remain unaffected by decay is of central importance to the problem of slow reading.

The phenomenon of decay must be seen as distinct from overloading STM with too many items or chunks, which would be a problem to all users of nonsense syllables, digits, list words and even users of a natural language. In the case of overloading, psychologists talk about 'interference' — too many items jostling with each other for limited storage space in STM — while in the case of 'decay' the temporal capacity of the store to retain items has been exceeded, and in the absence of conscious rehearsal on the part of the subject the items vanish rapidly without leaving a trace in LTM. • Craik and Lockhart (1972) after reviewing the relevant literature have estimated the temporal capacity of the STM store to be 'up to 30 seconds'. This appears to be a fair summary. Usually STM experiments require immediate recall or recall within 30 seconds of presentation. Martin and Walter (1969), for example, tested recall of items at 0, 10 and 30 seconds retention intervals.

Many experimenters do not bother to specify what they see as the exact time limit of STM, but their judgement of its temporal capacity is implicit in the retention intervals built into their experimental design. The classic study on decay in STM by Peterson and Peterson (1959), which spawned so many similar ones in its wake, resulted in the finding
that the forgetting of consonant trigrams was almost complete after 18 seconds if subjects had been prevented from rehearsal by the imposition of a distractor task at the end of the trigram presentation.

From the foregoing it may appear that investigations into STM capacity have been restricted to material which is of little interest to the linguist. This is not the case at all; but compared to the large number of experiments that have employed atypical material, studies based on linguistic units like the clause or the sentence are in a distinct minority. Two of them have reached something like the status of classics in their field. One is the 1965 Savin and Perchonock study on the amount of STM space taken up by sentences exhibiting various grammatical features such as negative, passive, wh-transformations, etc. The other is the 1967 work by Sachs on the memory for lexical, syntactic and semantic aspects of connected discourse.

Savin and Perchonock started with the assumption that STM has a small fixed capacity and that sentence processing in STM is influenced by the number of grammatical transformations (Chomsky, 1957; 1965) a sentence has to undergo in its derivation from deep to surface structure. Using an Archimedian experimental technique whereby subjects had to recall different individual sentences along with a list of unrelated words, it was found that sentences requiring more transformations than others reduced the number of words that subjects could recall along with it. Savin and Perchonock argued that the more complex the transformational history of a sentence the more working space is taken up by it in STM for processing. Their thinking was in line with the position taken by Miller and McKean (1964) who found experimental support for the idea that processing time for a sentence increased with the number of transformations in its derivational history. The results in the Savin and Perchonock experiment were clear-cut and allowed elegant and consistent predictions to be made about the STM space.
taken up by each transformation.

Later replications of the experiment by Matthews (1968), Glucksberg and Danks (1969) and Epstein (1969) have thrown serious doubt on the original Savin and Perchonock formulations. These studies failed to reproduce the convincing results of the original study, and it has been suggested that sentence length was not adequately controlled by Savin and Perchonock, so that the sentences which ranked highly on their scale of derivational complexity at the same time contained the greatest number of words. According to Brown and Herrstein (1975) virtually all of the recall scores in the Savin and Perchonock experiment could have been predicted from a simple word count of the sentences involved. Similarly, Reynolds (reported in Reynolds & Flagg, 1977:262) showed that the results from the Miller and McKean retention-time study could well have been the artifacts of the experimental task and the particular semantic properties of the sentences used.

Sachs (1967) asked subjects to detect changes in the lexical, syntactic or semantic form of certain sentences embedded in connected discourse after intervals of zero, 80 and 160 syllables. Her findings showed that after an interval of 80 syllables of running texts, which she equates to about 27 seconds of time taken, recognition of syntactic changes was close to chance while changes in the meaning of sentences were recognized quite successfully. Similar results to Sachs were obtained by Wanner (1974) in a series of experiments.

Jarvella (1971) obtained some interesting results with an equally ingenious research design. His findings can be summarized as pointing to the most recently heard sentence and clause as the units being processed in STM, while a previously heard sentence had already been passed into long-term storage with surface structure forgotten but meaning well preserved.
Certain results from experiments using the well-known 'click' paradigm introduced by Ladefoged and Broadbent in 1960 were interpreted as indicating that processing load for the human perceptual system is particularly high at the very end of clauses. This in turn has been interpreted as being supportive evidence for the notion that STM is used to store the various incoming constituents of a clause until they are ready for final processing when the clause boundary is reached (Fodor, et al., 1974).

Taking stock of the relationship between a hypothesized short-term memory store and language processing we find that STM is assumed to have a limited capacity both in how much and how long it can hold items for further processing. This picture of STM derived from experimental psychology, where more likely than not atypical material is presented in atypical tasks, has been used as an explanation for real or apparent phenomena observed by workers in fields concerned with human beings' ability to communicate through a natural language.

Although a small proportion of studies have used stimulus material larger than individual, unrelated words, none of these have addressed themselves to the question of what happens if the processing rate is so slow that it exceeds the temporal limits of 'up to 30 seconds' postulated for STM. The reason for this neglect may be that a suitable research design has not immediately been evident; obviously the simple solution of merely slowing down presentation rates to a suitable level cannot be the answer since this will give subjects added opportunities for rehearsal - the process said to maintain information in STM.

One experiment reported by Flores D'Arcais (1974) had junior primary school children write down verbatim previously heard sentences. Because of the inherent slowness of writing itself and the lack of fluent writing skills in these small children, the postulated time limits of STM would have
easily been exceeded. However, it should be noted that the children in this particular situation exceeded the assumed limit during the recall phase of the experiment, while the original processing of the sentence took place well within STM capacity as the presentation of the sentence material proceeded at the normal rate of speech, taking only a few seconds for each sentence to be delivered. Hence, no conclusions could be drawn from this experiment about STM capacity and language comprehension, especially as the children did not even have to demonstrate comprehension of the sentences but merely verbatim recall.

It is, nonetheless, quite easy to reverse the two temporal aspects of the presentation and recall modes; i.e., find a naturally occurring situation in which slow processing rates are a common feature and follow this by an almost instantaneous test of comprehension, including if possible, all elements of a sentence. Such a research design would seem to provide a valid instrument to test the claim that a hypothesized STM with a specifiable upper limit in processing capacity has actually anything to do with how successfully human beings understand sentences in connected discourse.
NOTES - CHAPTER II

1. For a detailed description of this parallel development in linguistics and psychology away from mentalism towards empiricism, see Blumenthal (1970).


2a. Judging by the huge number of studies still being conducted within a very much empiricist paradigm and reported in the equally impressive number of psychological journals on the market.

3. These remarks are mainly directed at studies in human memory and in particular its short-term aspects.

4. A similar thing seems to have happened to the Chomskyan type of generative-transformational grammar which is being drawn on by many workers outside linguistics proper.

5. A perusal of any of the many psychological journals reporting memory research will provide examples of this type of approach.

6. Tulving and Madigan sampled 540 publications representing slightly less than 50 per cent of all relevant publications in the latter part of the 1960s. While not having the same breadth of knowledge and understanding of the field as these two reviewers, the writer has come to similar conclusions after having read only a fraction of the existing literature on the subject. For a more charitable view on the merits of recent research into human memory, see Postman (1975).

7. Craik and Lockhart include a 'sensory register' in their summary. Their register is a component in most multi-store models of human memory. It is, however, of no particular relevance to the question under investigation but is included for the sake of providing a complete picture.

8. The reference is to mature subjects adopting these strategies as it is generally acknowledged that in children of the age which took part in the study described in Chapter 3, rehearsal skills are either absent or poorly developed. (See Chi, 1976, for a review of the evidence for this).

9. In this paradigm subjects hear sentences with a 'click' superimposed on them. Subjects are required to report the position of the 'click'. Accuracy and reaction times for 'clicks' located towards the end of a clause are reported to be worse than when they occur towards the beginning of a clause.
See p.25
CHAPTER III

THE EXPERIMENT

Considerable differences exist between the tightly controlled experimental paradigms and laboratory settings of experimental psychology and the tasks and situations encountered by people in everyday life. Nevertheless, experimental findings are quite often extrapolated and generalized to the real world without due regard for the possibility that laboratory-type experiments may encourage or even force people to adopt unusual strategies to solve 'problems' devised solely for the purpose of the experiment, with little or no opportunities for application outside the laboratory.

Criticism that the results of experimental psychology are often of little relevance to practically-oriented disciplines such as teaching is nothing new, but there are signs that even fairly conservative sections in psychology are beginning to become aware of a change in research design away from the 'agricultural' type towards a more 'social-anthropological' paradigm. The latter lacks the tight controls of empirical research but taps something which is more likely to provide insight into how people deal with naturally complex but meaningful tasks, e.g., understanding and remembering a story as contrasted with the simple but meaningless and quite uncommon demand of learning and memorizing a string of nonsense syllables.

With these preliminaries in mind, the design of the present 'experiment' was aimed at resembling as closely as possible the features of a 'real life' situation in physical surroundings, personnel, experimental materials, task requirements, maintenance of established routines, etc. In doing so it was expected that a subject would not really be aware of having been placed in a special situation and that he would accept the task given to him as a fairly natural activity, identical or closely related to activities he normally engaged in. Put in such a situation one would expect the
subject to employ the same or similar strategies to those he adopts unconsciously and as a matter of course in a wide range of common everyday tasks. At the same time the experimental situation and the associated task had to be such that some valid conclusions could be drawn from the results regarding the problem under investigation; i.e., the alleged existence of a specialized memory (= STM) and the crucial role it is claimed to play in the processing and understanding of natural language.

The subjects involved in the study, therefore, had to be confronted with natural language, preferably in the form of connected discourse, and their comprehension of it tested immediately after presentation to bring to light any influence that STM limitations, either in the dimension of storage space or processing time, may have had on the subjects' ability to process natural language units such as sentences.

Looked at from this point of view, comprehension becomes a function of STM. To put it differently, if a sentence can be understood within the limits postulated for STM and if the same or a parallel sentence which exceeds these limits cannot be understood or can only be partly comprehended by the same person, this would constitute strong evidence for the view that STM limitations had prevented or interfered with the comprehension process.

The difficulties of finding a satisfactory definition of language comprehension and ways of measuring such comprehension have been reviewed by Carroll (1972). If one accepts a broad definition like 'comprehension is the apprehending of meaning' one is left with the problem of defining 'meaning'. The explication of 'meaning', however, seems to be even more formidable and beset with difficulties, as Carroll rightly points out.

In order to test comprehension per se one might want to exclude from the test material, as far as possible, all
those aspects of meaning which require various reasoning skills or a specialized knowledge of the world. For the purpose of the present study, it was therefore decided to adopt a grassroot-level view of meaning and accept as minimal operational definition, with respect to the comprehension of a sentence, a person's ability to 'identify meaningful segments and grammatical relations among them' (Garrett, 1974).

Various techniques for testing comprehension of natural language were considered for the present study. A number of different tasks have been used in the past to assess language comprehension (Carroll, 1972), but none of these seemed suited to the particular requirements of the problem under investigation. Imitation (verbal recall) measures were rejected because successful performance in these does not necessarily indicate the degree of comprehension attained, and, given the commonly held view that children's language comprehension exceeds their power of language production (Fraser et al., 1973), imitation measures cannot be regarded as a reliable indicator of comprehension.

The traditional question and answer technique had to be excluded because a single question cannot usually test all 'the meaningful segments in a sentence and the grammatical relations among them'. Furthermore, the question itself will provide the subject with partial information about the original sentence.

Verbal or picture verification tasks disqualified themselves in that they, too, provide the subject with information about the original sentence or can only test certain aspects of it at any one time. Paraphrasing, a variant of the reproduction task, was considered and rejected on similar grounds. A child's inability to produce an accurate paraphrase may not lie in his ability to comprehend the message but to recreate it in his own words.

Various other procedures were investigated and rejected
until the most promising approach left was some kind of
task involving a non-verbal response to the message.
Commands or instructions are the most obvious forms that
can be tested with this approach (Jones, 1966; Shipley
et al., 1969), but Carol Chomsky (1969) has successfully
adapted the technique for use with other types of sentence
construction. A non-verbal response task does not draw on
the subject's ability to produce language; can be so
designed as to give the subject no worthwhile hints about
the original message, and can be carried out by the subject
immediately the message has been received and without any
further distracting factors being introduced between it and
the response itself. One obvious restriction inherent in
this technique is that the meaning of any message to be
tested has to be of a fairly concrete nature so that its
various constituents have demonstrable physical correlates.
However, in the light of the subjects' ages, the nature of
the problem and our adopted definition of comprehension,
this limitation was not considered vital.

At this point it will be appropriate to state the problem
once more. It simply asks whether it is true that when
language is received at too slow a rate (violating the
postulated limits of a hypothetical STM) comprehension will
suffer. In a speech situation under normal conditions this
problem does not arise. If widely used elements of a common
grammar plus a shared knowledge of the world are the
ingredients of such a situation, then the range of speech
rates that has been observed (Goldman-Eisler, 1968) must be
at least compatible with a listener's ability to process
the incoming language. There do not seem to be any demands
on record that people generally should speed up or slow
down their speech in order to facilitate communication. The
answer to our question then must be sought from a population
that has to cope with rates of language input substantially
below the range of ordinarily observed speech rates.

While there are any number of studies (in Ducker, 1974)
that report the effect of artificially increased speech rates, Orr, in the same volume, laments the dearth of research and application of expanded (or slowed) speech. Stroud (1967) managed to artificially expand normal speech to 2.9 syllables per second below which auditory flutter set in and distorted the quality of the recording. The rate achieved by Stroud, however, is not much below that of ordinary speech, which centres around 3.5 syllables per second for the material employed by him. Riding and Shore (1974) in their experiment with subnormal children made a recording of their test passage by having it read at a deliberately slow rate and then inserting additional pauses to get a rate of 73 words per minute. Given that the material used works out at approximately 1½ syllables per word on the average, the translated rate would still be about 110 syllables per minute or nearly two syllables per second, a rate which is considerably above that observed for Aboriginal children during oral reading (cf. Chapter I).

A drawback associated with the Riding and Shore technique is that the inserted pauses allow the subject time to process what he has heard without the interference of new incoming material. While this was a stated objective in their experiment it would obviously not be a valid technique in the present case as the 'reserved' pauses would allow subjects time to put into operation rehearsal strategies (Atkinson & Shrieffin, 1968), a control process in STM which does not seem to be operating in the performance of slow readers. This point will be taken up again in the discussion of results (Chapter V).

Since it appeared impossible to achieve the slow language input rates observed for the slow reading Aboriginal children in anything remotely naturalistic as far as linguistic quality and experimental task and setting was concerned, it was finally decided to use the most obvious source of slow language production; i.e., the slow oral reader. This solved the problem of naturally occurring slow language
input as well as providing ready-made solutions to a number of previously stated conditions thought desirable for the conduct of the experiment. The school would provide the natural setting and the children's reading teacher would administer the experiment. The task itself would involve the reading aloud of a piece of prose from a book, an exercise most slow readers would be very familiar with. The final part, during which the children would have to demonstrate their comprehension of what they had read, could be so constructed that the task appealed to the children's play instinct and avoided the atmosphere of a formal test or a special occasion.

One inherent problem with the scenario outlined was the danger of confounding a possible impairment of comprehension brought about by an interaction of slow reading rate and limited STM capacity on the one hand and some deficit in a child's language comprehension per se on the other. In order to eliminate the latter possibility it was decided to pre-test all subjects on a listening task involving a parallel version of the text to be eventually used for the reading task.

M E T H O D

Subjects

Altogether 25 boys and 25 girls ranging in age from 6:2 to 9:8 took part in the study. They comprised 36 slow readers and 14 skilled readers. The children were selected on the basis of existing reading groups in the school. The slow readers were made up of 13 first graders who, because of their limited experience in formal reading (less than one year), made up a natural group of slow readers; 9 second and third graders who had been assigned to the lowest reading group in the school on the GAP Reading Comprehension Test (Revised edition, 1970); 9 migrant children who attended special ESL classes and who, because of their restricted knowledge of English compared to their English-speaking peers, could be expected to read more slowly.
in English; 5 children attending a so-called OA class catering for children with a range of learning difficulties including reading. The 14 skilled readers made up the top reading group in the lower primary division of the school. This last group of children was chosen in order to provide some measure of comparison between good and poor readers on a task which, to the writer's knowledge had not been administered anywhere previously. No children above Grade 3 were chosen as the writer was unsure whether older children would enter into the playful spirit of the comprehension task or consider it too childish for their age.

**Design**

This involved a 2 (low v. high reading ability) by 2 (listening v. reading task) 2-way split plot analysis of variance using unweighted means solution for an unequal number of subjects with reading ability as between subjects variable and recall/comprehension task as within subjects variable.

**Materials**

Two pieces of prose (Appendix A) were constructed by the writer, consisting of 22 sentences each that were judged to be parallel in length, vocabulary items, syntactic structure, and general conceptual difficulty. One general criterion for generating individual sentences in the two stories was that they had to be as similar as possible to those that children encountered in their 'real' reading materials. To this end, the writer surveyed a number of basal and supplementary readers available at the school and extracted various sentence and clause types which were compatible with another criterion for sentence selection; i.e., sentence length within the stories had to be systematically varied in order to produce a rough effect on reading times. The expected variations in reading time were
a necessary requirement to test the decay hypothesis for losses occurring in STM. Furthermore, longer sentences could be expected to provide a subject with more material to process than shorter ones, and this condition was required to test the overload-pushout notion as another control process in STM (see Chapter II for an explanation of these processes).

Sentence length varied from 4 syllables, or 4 words, to 31 syllables or 23 words. The relation of sentence length to sentence complexity and its possible effect on comprehension is not taken up at this stage but will be discussed later.

The two parallel versions of the story were achieved by generating an original version and then in the second version substituting selected lexical items or changing the relationships that existed among them. Thus, in the original version of the story, Sentence 3 was The little dog runs after the ball and Sentence 6 was The little sister is crying. The parallel version had the little brother running after the ball (Sentence 3) and the little puppy barking (Sentence 6).

The two versions of the text were submitted to the subjects' five regular class teachers who were invited to judge whether the stories would present any linguistic or conceptual problems when told to, or read by their pupils, or whether the content and style differed to any great extent from what may be found in an ordinary basal reader. The teachers professed themselves satisfied as to the suitability of the stories on all counts.

Version 'A' of the text, together with a shorter, unrelated practice passage, was then recorded by each teacher at their normal story-reading speed on a Uher tape recorder at 7½ inches per second speed. Version 'B' was typed in large black type, one sentence per page, on heavy white paper and bound into the covers of a commercially produced picture book with the fortuitously suitable title of MAKE A STORY.
Corresponding to the various actors, objects, locations etc. which occurred in the two stories, physical counterparts were prepared in the form of cardboard and plywood cut-outs that could easily be manipulated by the children to demonstrate the different action verbs contained in the stories. In addition to the concrete correlates of the story elements, a number of similar but contrastive figures were added to the collection to act as distractors. Thus each cut-out which represented an element from the text contrasted with at least one other, which did not occur in the text, at one or more levels of discrimination and categorization; e.g., a number of dogs of different size and colour would contrast with each other as well as with some other common animals which had no part in the stories. A car in front of the supermarket contrasted with a car in front of the school; and this in turn had to be distinguished from a truck near the supermarket, etc. Thus, in order to demonstrate comprehension in accordance with the definition of comprehension given earlier, subjects had to identify and somehow retain all the meaningful elements of a sentence whatever they might be and the relations that existed among them.

Procedure

Since one of the design criteria for the experiment was to make the context in which the children were to be tested as natural as possible, the writer was introduced to the children as a new teacher and posed as a reading tutor assigned to the various reading groups in the school throughout the duration of the experiment (4 months). He took part in a number of other curricular and extracurricular activities around the school and attended school on the basis of a regular staff member. From the behaviour and reactions to him of all the children the writer came into contact with, it can only be concluded that they regarded him as nothing more than a regular teacher giving regular lessons. Before the experimental sessions, he gave or took part in a number of conventional
lessons involving all groups.

The room in which the experiment itself was conducted was the partitioned-off section of an ordinary classroom which normally served a number of purposes, including teachers taking children there for individual instruction. The room was left in its usual condition, and any materials associated with the experiment, but not required by the subjects, e.g., tape-recording equipment, were hidden out of sight.

The experiment consisted of two parts given three months apart. Individual children completed their sessions in the course of their normal scheduled reading lessons with the writer. This lesson always fell in the period before lunch. Sessions were held regularly except where the school had organized extra-curricular activities for a particular day.

The first part of the experiment required the subjects to listen to and demonstrate their understanding of version "A" of the text after first having shown their understanding of what was required of them by completing the shorter practice passage. Each subject was tested individually by the writer in his role of teacher during one of the regular periods set aside for reading lessons. Before listening to the recorded text all subjects were asked to identify by name all the cut-out figures on view, regardless of whether they had a part in the story or not. This procedure was to ensure familiarity with the lexical items in the text and to rule out the possibility that failure to comprehend later could be blamed on difficulties with vocabulary items. All subjects were given identical instructions as to what they had to do. They were told that they were going to play a game in which they had to 'make a story' after having heard it read by their class teachers on tape. They were told that they had to 'make the story' by using the cut-out figures provided and that they had to act out whatever they had heard, whenever the recording stopped. This was in effect done after each designated sentence through remote control of the tape-recorder from which the sound
was relayed to a high-quality speaker placed on the bench, which also contained the display of the test material. The broadcast was resumed as soon as a subject had demonstrated his comprehension, or lack of it, of the previously heard sentence. During a subject's performance a record was kept of the individual's errors, omissions and any unusual factors which might have influenced his performance. Feedback was restricted to positive remarks like 'good', 'fine' and other small encouraging noises. Any responses which appeared to be ambiguous as to the intended meaning were clarified by asking specific questions about the doubtful element(s) involved.

Any apprehension held by the writer as to how the subjects would handle or react to the task were dispelled during the practice run. All children picked up very quickly what was required of them and seemed to enjoy playing the 'game'. There were no signs of inattention, boredom or fatigue that were judged to be of any significance as they went through the 22 sentences.

Version 'B' of the text was administered to each individual three months after Version 'A'. This interval was judged sufficient to allow forgetting to take place of all but the most general information about Version 'A'. As it turned out all subjects had only very vague and often inaccurate recollections about it. Subsequent inspection of results from the two versions showed no evidence that the first pro-actively facilitated or interfered with recall for the second. However, subjects remembered the task requirements sufficiently well so that further practice runs did not prove necessary. As with the earlier version all subjects had to demonstrate their familiarity with all of the cut-out figures used in the new version of the text as well as those provided as distractors. Subjects were then shown the book 'Make a Story' and instructed to read aloud what was on each page and then to 'make the story' with the help of the cut-outs in the same fashion as on the first
occasion. They were also told that the new story was not the same as the earlier one. Subjects then read the text sentence by sentence. After the reading of the last word of a sentence the page was flipped over on to a following blank page and the subjects attempted to demonstrate their retention and understanding of it through appropriate manipulation of the cut-outs. Subjects were not given any assistance with decoding unless they:

a) specifically asked for a particular word they could not decode themselves,

b) misread a word or group of words in a way which would have made it impossible to demonstrate its meaning with the means available, or

c) completely gave up in their attempts to decode a difficult word and were in danger of losing concentration.

In these cases the writer simply supplied the necessary word(s) without any further comment. The reading aloud plus any associated verbal exchanges between a subject and the writer were recorded on a concealed Uher tape-recorder. Again all children cooperated willingly with the writer and appeared to enjoy the 'game' even though for many it must have been quite an effort considering the poor oral decoding skills they exhibited. All children completed the task.

Observable differences in the rate of reading between the slower and faster readers could be attributed in virtually all cases to decoding difficulties experienced by the slower readers. As the sentences were read aloud it was possible to monitor exactly where these difficulties occurred and how the slow readers attempted to deal with them. Invariably they made attempts to 'sound out' the troublesome words and these attempts could take up to twenty seconds in some cases before the word was either decoded successfully or some assistance was offered. An inspection of the reading data did not reveal any specific pattern of decoding difficulties as the words which caused these difficulties varied considerably from individual to individual.
NOTES - CHAPTER III

1. The writer himself was a subject in two typical perception/memory experiments (courtesy Psychology Department, Australian National University) and found it difficult to relate the contexts/task requirements of all the experiments to anything his senses/memory might be called upon to do for him in real life.

2. Research covering the most important areas in psychology is regularly reviewed in the Annual Review of Psychology.

3. See, for example, the editorial of The British Journal of Educational Psychology, Vol.45, No.1, 1975 (from which the terms 'agricultural' and 'social-anthropological' were borrowed) on shifts in methodology in experimental psychology.

4. Language comprehension ability may be impaired in a number of ways including, in the present context, lack of competency in English by speakers of another language or a possible mismatch between level of linguistic/cognitive development and the linguistic form/semantic and pragmatic content of the text. As will be seen, the level of the text in these respects was pitched at a level estimated to have been attained by all the different groups of subjects in the study.

5. Narrabundah Primary School, Canberra, A.C.T. The children who took part in the study represented the total reading population available at the school for the two extreme ends of the skilled-unskilled continuum for reading English prose.

6. The children's regular teachers rather than the writer himself were chosen to make the recording for the following reasons:
   a) a somewhat artificial situation would have been created by having the story come from a recording when the teller himself was present;
   b) the writer was still relatively new to the children and the unaccustomed voice plus a slight non-native accent could have been blamed as a possible source of comprehension difficulty;
   c) by having children listen to a recording the writer was free to observe and, if necessary, to record his observations without having to interrupt the proceedings unnecessarily.

7. The statistical analysis described was arrived at post hoc. It was suggested after consultation with one of the external examiners (Dr. O. Katchan) who also pointed out a number of faults in the design of the project such as the failure to explicitly state a Null Hypothesis, and the lack of control for intelligence level and age. This must be seen as a particularly serious omission as the results eventually obtained from the experiment may well have been influenced by variations in cognitive ability. As it is, the only measure of intelligence
available for the population is based on the distinction made between the OA children - mildly retarded, IQ 80 - and the rest, presumably normal, IQ 80 +. Another shortcoming of the design was that the order of presentation (the 'A' and 'B' versions of the text) did not vary and neither was there an alternation of order in the listening and reading tasks. However, it should be pointed out that the listening task was proposed in order to detect (and eliminate from the subject population) any children with serious language processing deficits as distinct from reading disabilities.

I am grateful to Dr. Katchan and the other examiner (Professor R. Wales) for their critical but sympathetic comments on the weakness in design of the study. I wish I could have redone the experiment along the lines suggested by Dr. Katchan, but this proved impossible as shortly after its completion I relocated, physically and conceptually, to areas removed from those in the present study.
An inspection of the results obtained under the listening condition indicated that neither the language nor the conceptual level of the 'story' created major difficulties for any subject. Overall comprehension and memory for details appeared to be rather good judging from the number and nature of 'mistakes' that did occur. Because of their apparent ability to deal with the experimental materials linguistically, conceptually and pragmatically, all subjects were left in the study and completed the reading task after a three months' interval.

The results for all fifty subjects originally selected for the study are analyzed below under the following headings:

. Comparison of listening and reading performances (including the application of ANOVA to main and subgroup error scores and Sign Test to compare individual performances using a weighted error scale).

. The nature of impairment in the reconstruction of heard and read sentences (broad classification of error types - loss; substitution; reduction and addition).

. Impaired ability to reconstruct sentences correctly after reading as a possible function of:
   a) slow reading times in excess of postulated temporal STM capacity (charting of reading speeds and error rates);
   b) serial position of sentence constituents (tabulation of affected position in a sentence),
c) grammatical membership of sentence constituents (tabulation of errors affecting different grammatical categories at the sentence level),

d) other observations.

Listening and Reading Performances Compared

A preliminary inspection of individual results showed that comprehension (or memory?) after reading as being somewhat inferior compared to listening; i.e., more items of various sorts were forgotten, substituted, reduced or modified in some way after reading than after listening.

To see how an individual's performance compared under the two measures an error score was worked out for each individually heard and read sentence. In the absence of any established scale which assigns plausible values to the different elements comprising a sentence, an ad hoc sliding scale based on some broadly defined grammatical criteria was applied to sentence elements which were part of the original text but which subjects either reproduced incorrectly or not at all. The scale and examples of its application are shown in Appendix C.

For each subject results from reading and listening for the twenty-two sentences were compared by means of Sign Test (Robson, 1973) to determine whether reading performance was significantly inferior to listening performance. The results showed that on this measure only seven subjects were significantly inferior at the five per cent level (see Appendix D). The results for the two hypothesized groups (slow = poor readers, fast = good readers) on the listening and reading tasks are summarized in Table 2.
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<th>N</th>
<th>Reading Equal or Superior to Listening</th>
<th>Reading Inferior to Listening</th>
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<tbody>
<tr>
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<td>29</td>
<td>7</td>
</tr>
<tr>
<td>Fast Readers</td>
<td>14</td>
<td>14</td>
<td>-</td>
</tr>
</tbody>
</table>

Memory/comprehension performance of slow and fast readers after hearing and reading two parallel story versions; Sign Test, p.101

It should be noted here that while the figures show that seven of the poorer readers performed significantly worse after reading, this number is less than 20 per cent of the total number of subjects in that category. In other words, slightly more than 80 per cent of the slow reading group had a reading score which was comparable to their listening score.

It is, however, of interest to see what particular subgroup those seven slow readers came from. Two are first graders (n = 13); two are from the ESL group (n = 9) and three from the .OA.class (n = 5), while the remedial group contained no reader whose performance after reading was significantly inferior compared to listening on the measure used (see Appendix D for details of the worked Sign Test). The poorer performance of the OA children over the first graders and ESL children relative to their numbers and in comparison with the remedial and skilled groups of readers is also reflected in the results of the analysis given below.

A comparison of the number of individual sentences heard or read which exhibited some loss or deviation from the original text shows that for the better readers the average number of sentences reconstructed incorrectly is only slightly greater after reading than after listening. Differences between listening and reading for the poorer readers
is more marked, but it is interesting to note that, for a start, listening comprehension for this group, particularly for the mentally more immature first graders and OA pupils, is inferior compared to that of the better readers. The differences for each group and sub-group in the number of sentences reconstructed incorrectly after listening and reading is shown in Table 3.

**Table 3**

<table>
<thead>
<tr>
<th>Group</th>
<th>Average Number of Sentences Reconstructed Incorrectly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>a) After Listening</td>
</tr>
<tr>
<td>Slow Readers</td>
<td></td>
</tr>
<tr>
<td>1st grade</td>
<td>3.2</td>
</tr>
<tr>
<td>OA</td>
<td>2.8</td>
</tr>
<tr>
<td>ESL</td>
<td>2.0</td>
</tr>
<tr>
<td>Remedial</td>
<td>1.8</td>
</tr>
<tr>
<td>Slow Readers overall</td>
<td>2.5</td>
</tr>
<tr>
<td>Fast Readers</td>
<td>1.6</td>
</tr>
</tbody>
</table>

Differences between slow and fast readers in number of sentences reconstructed incorrectly following hearing and reading two parallel story versions.

Table 3 shows that on the whole faster readers performed better under both conditions; a point that will be taken up again in Chapter V.

Submitting the data to a Two-way Analysis of Variance (Glass & Stanley, 1970) showed that overall the slow readers reconstructed significantly fewer sentences correctly than the fast readers \( F (1,48) = 19.65, p < .001 \) There were also significantly more reconstruction errors after reading compared to listening \( F (1,48) = 31.11, p < .001 \)
and significant interaction between reading ability and task modality \[ F(1, 48) = 16.26, \ p = .001 \]. In other words, the results indicate with a high degree of statistical probability that low reading ability is associated with more errors in the reconstruction of sentences read than sentences heard over what that difference is for high reading ability.

Because of the observed variation in the data for the various subgroups of slow readers it was further decided to compare each of these subgroups against the group of poor readers using the same statistical method. The results are summarized in Table 4 (see Appendix E for more details).

**TABLE 4**

<table>
<thead>
<tr>
<th>Sub-groups</th>
<th>Ability</th>
<th>Modality</th>
<th>Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast x Remedial</td>
<td></td>
<td>**</td>
<td></td>
</tr>
<tr>
<td>x ESL</td>
<td>**</td>
<td>***</td>
<td>*</td>
</tr>
<tr>
<td>x 1st Grade</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
<tr>
<td>x OA</td>
<td>***</td>
<td>***</td>
<td>***</td>
</tr>
</tbody>
</table>

* = p < .05  
** = p < .005  
*** = p < .001  

ANOVA significance levels for all sub-groups of slow readers

In addition to the differences among sub-groups of slow readers exemplified in Table 4 there is a substantially higher set of F-values for OA children over first graders (see Appendix E). Possible reasons for the differences will be discussed in Chapter 5.

The Nature of Errors in the Reconstruction of Sentence Meaning

So far, results have been described in terms of incorrect reconstruction of sentences. To see what kind of deviations
from the original text were likely to occur, all sentences were divided into their major surface structure components; i.e., subject and object noun phrases, main verbs and various kinds of sentence adverbials. Faulty reconstruction of any of these was analyzed as belonging to one of four possible deviations from the original reading:

a) the complete loss of a constituent; i.e., subjects omitted these from their reconstruction attempts altogether and could not recall them when questioned about them directly: e.g., 'The little dog comes back with the ball' → 'The little dog comes back';

b) the substitution of a constituent, or part thereof, with something else which was syntactically equivalent to the substituted element and semantically or pragmatically appropriate in the context of the story; e.g., 'Where did you kick my ball?' → 'Why did you kick my ball?';

c) the reduction of a constituent through the partial loss of one or more of its individual elements; e.g., 'a red ball' → 'a ball';

d) the expansion of a constituent by the subject adding one or more elements which were not part of the original text; e.g., 'William runs home and tells his mother that . . .' → 'William runs home and tells his mother and father that . . .'

Table 5 shows the total number of sentence level constituents which suffered these types of recall errors after reading and listening.

The total number of errors after listening is slightly less than 5 per cent of the potential total available and slightly more than 10 per cent after reading. Complete loss of sentence level constituents is relatively rare, being only approximately 1 per cent after listening and 3 per cent after reading. Table 5 shows that there is no strong trend towards any one of the four designated types of error.
TABLE 5

<table>
<thead>
<tr>
<th>Type of Error</th>
<th>After Listening</th>
<th>After Reading</th>
<th>Potential Total for Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss</td>
<td>47</td>
<td>145</td>
<td>No. of sentence level constituents</td>
</tr>
<tr>
<td>Substitution</td>
<td>67</td>
<td>158</td>
<td>for 22 sentences (89)</td>
</tr>
<tr>
<td>Reduction</td>
<td>44</td>
<td>119</td>
<td>x No. of subjects (50)</td>
</tr>
<tr>
<td>Addition</td>
<td>51</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>209</td>
<td>467</td>
<td>= 4,450</td>
</tr>
</tbody>
</table>

Number and types of error after reading and listening compared to the total number of potential sentence level constituents open to error.

While the total number of 'losses', 'substitutions' and 'reductions' increases after reading the same pattern does not apply to 'additions', after reading, subjects appear less inclined to embellish their reconstructions with extraneous ideas.

Possible Factors in the Retention of Full Sentence Meaning - Slow Input (Reading) Rate

The analysis of reading rates shows that the groups of subjects which were thought of as potential slow readers did indeed read much more slowly than the group which was comprised of children from the top reading group of the junior primary school. There was no overlap of reading speed scores between the two groups even though two subjects from the slower groups approached the speed of the slowest member of the faster reading group. While the reading rates obtained by the slower readers as a whole differed markedly from those of the top reading group, the average oral reading speed of the latter group was virtually identical to the average oral reading speed of the five teachers who had tape-recorded the listening version of the story. Table 6 shows the average reading speed for the various groups of
slow readers, the group of top readers and the five teachers who provided the narration on tape. 3

TABLE 6

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of Subjects</th>
<th>Reading Speed X (syll/sec)</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Readers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1st Grade</td>
<td>13</td>
<td>.46</td>
<td>.22</td>
</tr>
<tr>
<td>Remedial</td>
<td>9</td>
<td>.92</td>
<td>.53</td>
</tr>
<tr>
<td>OA</td>
<td>5 (-1)*</td>
<td>.50</td>
<td>.10</td>
</tr>
<tr>
<td>ESL</td>
<td>9 (-2)*</td>
<td>.87</td>
<td>.41</td>
</tr>
<tr>
<td>TOTAL</td>
<td>36 (-3)*</td>
<td>.68</td>
<td>.42</td>
</tr>
<tr>
<td>Good Readers</td>
<td>14</td>
<td>3.06</td>
<td>.71</td>
</tr>
<tr>
<td>Teachers</td>
<td>5</td>
<td>3.38</td>
<td>.34</td>
</tr>
</tbody>
</table>

* indicates number of subjects not timed during reading.

Mean reading speeds for different groups of readers.

There was marked variation in the overall reading performance among subjects. For example, one of the top readers (subject 48) read the story sixteen times faster than one of the 1st graders (subject 18). Variation also occurred within groups of subjects. For instance, subjects 7 and 9 (both remedial readers) read at an average of .43 syll/sec. and 1.99 syll/sec. respectively - a difference in reading rate of approximately five times. Finally, the reading rates of individuals for different sentences could vary dramatically from sentence to sentence as illustrated by subject 11 (a first grader) who read sentence 16 at a slow .11 syll/sec. and sentence 22 more than ten times faster at 1.17 syll/sec. Rates of reading combined with length of sentences to produce increased reading times and this had an effect on the number of errors for both fast and slow readers. When sentences are divided into 'short', 'short-medium', 'medium', 'medium-long' and 'long, it is immediately obvious that
regardless of reading speed the short sentences cause relatively few errors while the percentage of errors for all subjects increases markedly in the longer sentences (Fig. 2). In fact, the performance of the fast readers on the longest sentence (No. 3) in the story is only marginally superior to that of the slow reading group as a whole (see Appendix D). Figure 2 also shows that the optimum

**FIGURE 2**

<table>
<thead>
<tr>
<th>Sentences with Errors</th>
<th>Sentence Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>70%</td>
<td>short</td>
</tr>
<tr>
<td>60%</td>
<td>short-medium</td>
</tr>
<tr>
<td>50%</td>
<td>medium-long</td>
</tr>
<tr>
<td>40%</td>
<td>long</td>
</tr>
</tbody>
</table>

Percentage of incorrectly reconstructed sentences as a function of reading speed and sentence length.
reading speed for the most accurate retention of sentence content for our particular story appears to be around 2 syllables per second, which also happens to mark the upper and lower range of the slow and fast readers respectively. Above 2 syllables per second there is a tendency for accuracy to deteriorate slightly. Unfortunately, the number of subjects (= 14) reading above that speed is rather small and their rate of reading ranges up to 5 syllables/second, hence the pooling of results above the 2 syllables/second level. There is, however, an indication for errors by individuals in this group to increase at the upper limits of this speed range. Thus, it may be tentatively stated that the faster of the slow readers and the slower of the fast readers appear to retain a more accurate representation of a sentence in memory immediately after reading it.

Because of some of the very low reading rates achieved, absolute reading times for the longer sentences very often exceeded the upper-limit estimates for the temporal capacity of STM by a wide margin. All the slower readers, with three exceptions, exceeded thirty seconds reading time for a sentence at least once. Most managed to do so several times - one subject (No. 18) topping the count with eighteen sentences read variously between 36 and 99 seconds. There were also many sentences which took subjects between 20 and 30 seconds to read. This time span would probably be regarded by many experimental psychologists as already falling outside the temporal limits of STM judging by the time limits set in their experiments. None of the fourteen fast readers in the study approached the 30-second mark. In fact, the vast majority of scores for this group was well below 10 seconds, even for the longer sentences. The overall performance of each subject in terms of time taken per sentence read and the number of correct responses made is given in Appendix D.

It can be readily seen that reading times between 30 seconds and 90 seconds are quite numerous. (241 cases). Almost half
of all sentences where reading time exceeded 30 seconds were demonstrated with 100 per cent accuracy. If we disregard all those minor omissions and deviations from the original sentences which had only a marginal effect on meaning, the proportion of correctly reconstructed sentences would have been much higher. As the figures now stand only sentences which were reconstructed with all details intact were counted as correct while those which varied in any way from the original were scored as incorrect.

The results also show that with one exception all of the slow reading subjects whose reading time for a sentence was greater than the hypothetical upper limit of 30 seconds for STM succeeded in retaining correctly the expressed meaning of at least one of those sentences. The most successful in this regard were a first grader (subject 13) with 9 out of 13 sentences over 30 seconds completely correct and a remedial reader (subject 8) who scored 5 out of 5 correct.

The longest time taken for any sentence belongs to a first grader (subject 18) who took 99 seconds to read sentence 14 and demonstrated its meaning with almost 100 per cent accuracy. His demonstration of comprehension differed from the fastest reader (subject 44), who took about 4 seconds, only in the substitution of a relatively insignificant word at the very end of the sentence.

Instances where very slow reading times produced equal or better scores than fluent reading are also evident. For example, the longest reading time recorded for subject 13 (a first grader) was 94 seconds for sentence 13, a sentence he reconstructed with 100 per cent accuracy. His performance can be contrasted with the results of the three fastest readers (subjects 42, 44, 47) with reading times between 5 and 6 seconds, but who all suffered some recall difficulties on the same sentence.
Possible Effects in Memory of Serial Position in Sentences

Experiments involving the recall of items in a list have demonstrated again and again that the serial position of an item is a crucial factor in the success or failure of the item to be recalled. Indeed, since the consistent replication of results in one particular direction has been used as evidence for the existence of a STM store, it was only proper to look at what parts of a sentence were most often involved in the loss of elements or some other type of impairment in the case of readers who had exceeded the most generous temporal capacity hypothesized for STM.

Taking into account linguistic boundaries at the clause level, sentences were divided, as best as these boundaries allowed it, into three roughly equal parts: initial, medial and final. An analysis of the data showed that virtually any element regardless of its grammatical status or serial order position in a sentence was subject to outright loss or some other form of faulty retention - small one-item modifiers were as insecure in this regard as whole phrases and to a lesser extent complete independent clauses. No clear pattern of memory or comprehension impairment could be observed in relation to the position elements occupied in a tripartite division of sentences. Table 7 provides a summary of the results obtained from this analysis.

Looking at these not particularly revealing results, the objection may be raised that even though sentences were divided into roughly equal parts, elements within them were not likely to have been read at a steady rate, and no smooth curve of forgetting/remembering like those typically obtained in STM experiments (Cf. Chapter II, p. 13) during which items are presented to subjects at a steady predetermined rate could have been expected. That unskilled readers read at an uneven rate is, of course, quite true, and if all sentences as read by each subject were plotted along a time-taken scale, it would be safe to say that no two graphs
<table>
<thead>
<tr>
<th>Sentence Number</th>
<th>Number of Affected Elements in Sentence Position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
</tr>
<tr>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>2</td>
<td>12</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>8</td>
<td>7</td>
</tr>
<tr>
<td>9</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>0</td>
</tr>
<tr>
<td>12</td>
<td>2</td>
</tr>
<tr>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>15</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>17</td>
<td>4</td>
</tr>
<tr>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>21</td>
<td>0</td>
</tr>
<tr>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>TOTAL</td>
<td>80</td>
</tr>
</tbody>
</table>

Loss or distortion in retention of sentence elements in three different positions; reading time > 30 seconds.
would be identical except for subjects who could read with perfect fluency and exactly the same rate of articulation. However, it can be readily demonstrated that although reading rates were very uneven along sentences, faulty retention occurred at the very beginning and very end of sentences. In both these positions the primary and recency (cf. Chapter II, pp. 13-14) should have made elements safe if a sentence is merely seen as a string of independent words. Conversely, there were many sentences where the middle portion was perfectly retained when this is the section where according to STM theorists most errors are to be expected because of overload factors.

Looking at individual sentences no common pattern of impairment is obvious. Taking the two longest sentences in the story (3 and 19), which also took most subjects the longest time to read and produced the greatest number of omissions and other errors, it can be immediately seen that the majority of faults occurred in different parts of the two sentences. For sentence 3 the direction of error is medial (22), final (12) and initial (9) while almost the complete reverse holds true for sentence 19; i.e., initial (20), medial (4) and final (0).

A similar picture emerges when one looks at the pattern of errors for all subjects combined after both listening and reading. The four longest sentences (1, 2, 3 and 19), which also caused the greatest number of subjects to make errors, were selected for comparison. Fig. 3 shows the result of charting errors on a word-for-word basis along each of the four sentences after reading and listening.

Three things appear obvious. Firstly, error patterns for listening are similar to those for reading but at a lower level of frequency. Secondly, the pattern for all the subjects are comparable to those obtained for slow readers with reading times exceeding 30 seconds per sentence (cf. Table 7), and thirdly, following on from this, the patterns
Percentage of errors along four sentences (1, 2, 3 and 49) for all subjects combined after reading and listening.
produced by these four sentences are highly dissimilar from each other and do not fit the regular curve of forgetting found in the recall of list items (see Chapter II, p. 13).

Another group of sentences (4, 7, 8 and 17) which were similar to each other in that they were of medium length and required subjects to report spoken messages on behalf of the story characters, in addition to the physical manipulation of these characters, also yielded highly divergent patterns (Fig. 4)

FIGURE 4

Percentage of errors along four similar sentences after reading for all subjects combined
While the experimental materials were not designed with this in mind, it is nevertheless possible to make some limited, direct comparison of the chances certain syntactic constructions have of surviving intact shortly after having been heard or read as part of full sentences in a story context. These constructions are comparable since they appear side by side and with identical grammatical status in the same sentence; e.g., in the case of co-ordinated noun phrases, or because they occur across the whole range of sentences as in the case of subject noun phrases versus main verbs.

Some interesting but fairly tentative results were obtained. When comparing subject noun phrases, object noun phrases, main verbs and sentence adverbials across the spectrum of sentences, it was found that the main verb was clearly the most resistant to loss or substitution, followed by subject and object noun phrases, which were about equally well retained, while sentence adverbials suffered the severest rate of impairment. Table 8 shows adjusted figures for different sentence constituents suffering some kind of retention deficit after reading and listening for all subjects combined.

**TABLE 8**

<table>
<thead>
<tr>
<th>Sentence Constituent</th>
<th>Number of Errors</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>After Listening</td>
<td>After Reading</td>
<td>TOTAL</td>
</tr>
<tr>
<td>Main Verb</td>
<td>3</td>
<td>54</td>
<td>57</td>
</tr>
<tr>
<td>Subject NP</td>
<td>53</td>
<td>102</td>
<td>154</td>
</tr>
<tr>
<td>Object NP</td>
<td>23</td>
<td>98</td>
<td>121</td>
</tr>
<tr>
<td>Sentence Adv.</td>
<td>84</td>
<td>213</td>
<td>297</td>
</tr>
</tbody>
</table>

*Number of errors in the retention of sentence level constituents after reading and listening for all subjects combined. (Figures are adjusted for variation in the number of times a constituent type occurred).*
Some care should be taken when interpreting the figures in Table 8. While the salience of the main verb is clearly apparent, it must be remembered that the other constituents are often more complex in structure than the main verb and hence probably more liable to loss or distortion. Furthermore, the relatively large number of errors in the retention of sentence adverbials may have been aided by the fact that these adverbials occurred only in the somewhat longer sentences which generally were recalled more poorly than shorter sentences. However, the relative salience of the main verb is underscored by the very small number of errors associated with it in the listening condition—three errors out of a potential one thousand four hundred.5

Comparing constituents with identical status in the same sentence gives the results summarized in Table 9.

**TABLE 9**

<table>
<thead>
<tr>
<th>Constituent₁</th>
<th>No. of Errors</th>
<th>Constituent₂</th>
<th>No. of Errors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Main Verb₁</td>
<td>4</td>
<td>Main Verb₂</td>
<td>17</td>
</tr>
<tr>
<td>Subject NP₁</td>
<td>64</td>
<td>Subject NP₂</td>
<td>32</td>
</tr>
<tr>
<td>Object NP₁</td>
<td>23</td>
<td>Object NP₂</td>
<td>10</td>
</tr>
<tr>
<td>Main Verb</td>
<td>9</td>
<td>Subordinate Verb</td>
<td>22</td>
</tr>
</tbody>
</table>

*Number of errors for grammatically equivalent sentence level constituents occurring in the same sentence for all subjects after reading/listening combined.*

The figures in Table 9 provide some further slight support for the idea that the main verb behaves somewhat differently to other constituents with regard to salience or likelihood to be remembered correctly. For conjoined noun phrases the first member of a pair is more likely to attract errors than the second. The reverse is true for two main verbs.
Summarizing results so far we can say that:

a) retention of full sentence content immediately after reading showed more errors than immediately after listening for the majority of subjects;

b) after listening slow reading subjects, particularly the mentally more immature ones, were more likely to make errors than fast reading subjects;

c) there were differences among subgroups of slow readers on factors of reading ability, modality and interaction between the two with the more mature slower readers approaching the level of performance of the faster readers;

d) there was no clear pattern as to type of errors. Outright loss, substitution, reduction and addition were all likely to occur equally often, the exception being additions, which occurred less frequently after reading;

e) widely varying reading speeds and large variations in sentence length produced a wide range of total reading times per sentence. Many of these were up to three times greater than previously postulated STM limits. Nevertheless, nearly half of the sentences which produced these times were demonstrated with 100 per cent comprehension;

f) the length of a sentence had a more marked effect on the number of errors than the time it had taken to read it. For the longer sentences performance of the fast readers fell to almost that of the quicker slow readers;

g) serial position in a sentence was not a good predictor of errors. Errors occurred with roughly equal frequency along the whole sentence length when data for all sentences were combined. Other factors than serial position must be sought to account for various error-producing positions in individual sentences;
h) among broad grammatical categories at the sentence level the main verbs were best remembered, followed by noun phrases in subject or object position, and sentence adverbials were the most poorly retained.

Other Observations

Observing subjects during listening, reading and their attempts to reconstruct sentence meaning showed up a number of interesting features — some idiosyncratic to individual children, others common to a large number of subjects. The following are some of the more commonly observed features.

a) While reading, subjects produced a great variety of misreadings. Running into several hundreds, they were produced mainly by the slow reading groups. These misreadings were either self-corrected by the readers concerned or, if they could not be accommodated within the story context, by the experimenter. It was interesting to see that this sometimes massive number of corrections did not appear to create undue confusion in a subject's memory as invariably the corrected item rather than the original misreading showed up during the reconstruction phase; e.g.,

<table>
<thead>
<tr>
<th>as read</th>
<th>as corrected</th>
<th>as recalled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teddy</td>
<td>puppy</td>
<td>puppy</td>
</tr>
<tr>
<td>Don't go, darling.</td>
<td>Don't worry, darling.</td>
<td>Don't worry, darling.</td>
</tr>
<tr>
<td>Dad is behind the tree . . .</td>
<td>house</td>
<td>Dad is behind the house.</td>
</tr>
<tr>
<td>no, car . . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no, park . .</td>
<td></td>
<td></td>
</tr>
<tr>
<td>no, playground</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

b) Virtually all substitutions observed during the reading or reconstruction phases fitted the sentence syntactically and made good sense in the context of the story. This is strong evidence that many subjects, even though they were missing out on
accuracy as far as the original text was concerned, nevertheless must have a good grasp of the overall story structure and its content. They brought their own linguistic ability to bear where decoding skills, memory, attention or other abilities might have temporarily let them down; e.g.,

William runs home and tells his mother, "A big boy has kicked Tom". → Tom runs home and tells his mother, "A big boy has kicked me".

Where did you kick my ball? → Where is my ball?

c) A number of sentence elements or whole clauses underwent some form of transformation — not necessarily of the strictly syntactic type, but many involving a juggling and transposition of semantic or even phonetic elements; e.g.,

A big boy has kicked Tom → Tom has been kicked by a big boy.

. . . when they see Tom's father → . . . when Tom sees his father.

After that all the boys . . . → Father and all the boys . . .

d) Nine subjects claimed that they had completely 'forgotten' one or more sentences. However, when questioned they could recall sentence fragments but did not know how to fit them into the story context.

e) Overt verbalization by subjects during the reconstruction phase in the form of questions directed to themselves was observed in at least seven subjects. How many engaged in the same process covertly can only be guessed at. However, many of the hesitation pauses which were observed during this phase may well have served just this purpose.
f) Finally, while listening to the tape-recorded version of the story more than half the subjects consistently, and the rest sporadically, scanned the display of cut-outs as each sentence was being narrated. At the beginning of a sentence their eyes were usually focussed on the loudspeaker or the experimenter, but eyes turned to the display of cut-outs very quickly, moving apparently intelligently from one to another and fixating briefly on those that were being mentioned in the sentence. This active visual search while a sentence was being spoken could well be interpreted as evidence that sentence processing begins as soon as meaningful elements have been identified, and that processing of a sentence must already be well under way by the time a sentence has been fully received.

This concludes the presentation of what are considered the more important results emerging from the present study. Their implication in relation to a hypothesized short-term memory and its role in natural language processing will be discussed in the next chapter.
NOTES - CHAPTER IV

1. Malfunctioning of the recording equipment during the reading performance of three subjects meant that their reading rate could not be determined. However, the results of the demonstration-of-comprehension phase were recorded and have been included in the results for the total population.

2. It is often difficult, if not impossible, for an outside observer to assign either lack of comprehension or memory deficit as the cause of a faulty reconstruction attempt after hearing or reading a sentence. Terms like 'remembering', 'understanding' or 'retaining' a sentence will therefore be used interchangeably unless a distinction needs to be made.

3. Individual reading speeds were measured using a stop watch at the time of transcribing oral reading performance from tape.

4. Only sentence 3, which was also the longest sentence, contained two independent clauses joined by 'and'. It was the second clause which was sometimes 'forgotten' (by twelve subjects).

5. The number of main verbs (28) times the number of subjects (50) equals 1,400 potential errors.

6. Obviously, the grammatical status of main and subordinate verbs cannot be regarded as equivalent in a sentence. The comparison has been added to Table 8 to underline the apparent salience of the main verb in the immediate memory for sentences. Main and subordinate verbs are identified as the verbs occurring in the independent and subordinate clauses of a sentence respectively.

7. The values assigned were derived from linguistic criteria and no claim as to their psychological reality is made for the different linguistic categories employed.

8. It has been suggested by one of the external examiners that this finding is in conflict with what others have reported about children's scanning strategies. However, the scanning strategies as described here were one of the immediately obvious features of the children's listening performance in this context.

   It should be remembered that the children became very quickly involved in the experimental task and that the prospect of becoming visually involved with the (to them) attractive display as against the visual non-appeal of the loudspeaker could have been a factor. It should also be noted that the children were fully aware of the rules and objectives of the 'game' they had to play and that these factors combined may well have been sufficiently strong motivation to adopt the scanning strategies observed.

   One further observation which supports the claim that the children adopted an active scanning strategy during the listening task is the speed and non-hesitation with which they selected the appropriate cut-outs from the array of potential tokens.
CHAPTER V

DISCUSSION AND CONCLUSIONS

Multi-store models of memory have an appeal that is easy to explain. Their interconnected box structure is simple and allows one to see how incoming information flows along a well-defined pathway where it undergoes progressive processing (or rejection) in the boxes along the way until the final product can be stored away in convenient form for possible future consumption - a picture not unlike that of a conveyor belt carrying goods at varying stages of manufacture past processing stations in a factory. Capacity and other properties of such a system can be determined experimentally and described behaviourally or in a neat mathematical formula. Because of their intuitive attractiveness multi-store models of memory have provided the dominant paradigm for contemporary memory research. The notion of a memory divisible into short- and long-term components has found its way into other fields of inquiry including those concerned with the processing of natural language (see Chapter I). Here properties of the duplex system derived from experiments using atypical materials (see Chapter II) have been applied to natural language processing and used as explanations for real or apparent processing deficits exhibited by certain populations.

The short-term component of a duplex-store model of memory with its limited functions and storage capacity has assumed crucial importance in the discussion of information processing, particularly on the relevance of the model to certain language processing contexts such as reading, where the temporal capacity of the short-term store could be exceeded by slow readers, thus preventing adequate comprehension of what had been read.

The results of the experiment reported in Chapter IV will
be discussed below in the light of short-term memory as traditionally perceived, the possible need for a new model of STM not yet properly articulated, or an explanation of natural language processing which does away altogether with the distinction between short and long term memory.

Until recently STM has largely been seen as having a very limited capacity, and the temporal aspect of the store's capacity has been the focus of the present study. Claimed to be in the order of seconds, it has been used by specialists in the reading field to blame impaired comprehension on the part of slow readers on the limited temporal capacity of their STM being exceeded by the time they need to read a sentence.

This explanation has a certain appeal to it when one considers the input rates of very slow readers and compares them with rates of normal speech or what may be termed average reading rates. Without going into the age-old and perhaps futile question of the origins of speech and language, it may be assumed that speech rates have not increased or decreased dramatically over the thousands of years during which human beings have probably been in possession of language. Given that speech rates have stayed more or less within the range that can be observed today, it is perhaps not so far-fetched to argue that the human brain has become adapted to receiving and processing language within specifiable rates of input. The converse; i.e., that language and language users have adapted to certain natural limitations of the brain, can also be argued.¹

Normal speech and articulation rates have been extensively described by Goldman-Eisler (1968), and there is ample evidence from a number of studies (Sticht, 1974) that when presentation rates of speech are increased beyond the upper limits of those normal rates the result is a marked decrement in the comprehension of a message. Lenneberg (1967) speculates that the rate at which human beings can conceptualize incoming linguistic messages is the factor limiting
speech rates to approximately 210 to 220 syllables per minute (about 3.5 syllables/second) rather than the ability to perform high-speed articulatory movements which have been observed at rates of up to 500 syllables per minute (approximately 8.3 syllables/second) for short familiar phrases or cliches.

The question then is if the brain cannot handle language arriving at too fast a rate, may not the same be true if rate of input becomes too slow, particularly in the light of a constraining factor such as a STM store which can only hold material for periods measured in seconds. Unfortunately, the picture with very slow input rates is not as straightforward as with excessively high ones. While it is quite possible to compress (speed up) the presentation of speech mechanically to a considerable degree without much deterioration in the quality of sound, the reverse is possible only to a very limited extent (Ducker, 1974). Truly slow presentation rates can only be achieved by inserting relatively lengthy pauses at appropriate places into the stream of sound. However, these pauses allow hearers to rehearse previously heard material and so the question goes begging as the possible detrimental effects of slow input are offset by the benefits of rehearsal.

Within the framework of the present study naturally arising slow input rates were predicted for certain groups of readers. This prediction turned out to be correct when these readers were tested on a story reading task. Furthermore, close observation during reading provided no indication whatever of any rehearsal strategies being employed by unskilled readers engaged in what for most of them was a laborious word-for-word decoding process. It is difficult to envisage how rehearsal would take place under these circumstances. One has only to witness slow, unskilled readers trying repeatedly and apparently with great mental effort involved, to figure out what a particular word might be to rule out as very unlikely the possibility that such
readers are simultaneously engaged in the active but covert rehearsal of parts of a sentence that have already been read. On the contrary, it appears safe to say that all their attention at the time is focussed on decoding the particular word(s) which stand between them and a more fluent reading of the text. The slow readers in the present study seem to have provided genuine cases of slow natural language input and processing without the benefit of rehearsal. The requirement of holding information over exceedingly long periods of time should have resulted in the decay of items and, according to some popularizers of the STM concept, should have effectively prevented our slow readers from satisfactorily comprehending what they were reading. Yet there were numerous cases (cf. Appendix 'F') where subjects took far longer to read a sentence than had previously been considered within STM limits and not only achieved satisfactory comprehension but 100 per cent accuracy in the retention of sentence meaning.

Another direct contradiction of common beliefs about STM arises out of the result that forgetting curves for sentences did not follow the typical curve predicted by STM theory. Indeed, curves produced by the sentences in question cannot be said to follow any particular pattern. They appear to be idiosyncratic for individual sentences and particular elements within them. These results are similar to those obtained by the Mandlers (1964) on a serial learning task for sentences. What was learned first (and remembered in subsequent trials) were not words according to serial position in a sentence and favoured by primary or recency effects, but "those words which constitute the core meaning of a sentence . . . (units) representing the main communicative message of the sentence". (Mandler & Mandler, 1964:197, 201). Because their sentences varied in structure and content from each other, they also produced widely varying forgetting curves which differed markedly from those for unrelated words.
was completely omitted by a number of subjects while the other half, i.e. "... and says, 'Don't worry, (darling)"
was much better remembered. Sentence 8 is only of medium length and should not have attracted the number of errors it did compared to some other sentences of similar length. However, this sentence required subjects to use direct speech on behalf of the story characters, and this type of sentence (4, 7, 8, 17) attracted a higher proportion of errors than sentences of comparable length (12, 15, 22). Secondly, the word 'darling', in this sentence used as a term of address, was omitted by nine subjects even though it was the last word in the sentence. Combine this with the fact that some of the same subjects were also among those who could not remember '... gives him a kiss' and the explanation arises that some children in the age range selected (6+ to 9+) may have consciously or unconsciously rejected the idea of being kissed by Mum or being addressed as 'darling'. Twice as many boys as girls produced these omissions. Losses in other sentences may be explained with reference to the relative degree of salience some particular elements may have vis-a-vis others in the same sentence. However, it would seem unreasonable to argue that '... says, "Don't worry ..." has a greater degree of salience than '... gives him a kiss'. On the other hand it can be stated that grammatical markers and function words experienced indeed a very low level of salience: or how else can one explain that if a semantic content word was lost somewhere in the sentence, all associated grammatical markers indicating agreement, coordination, etc., elsewhere in the sentence did not remain in memory to alert subjects that something was amiss with their reconstruction of the sentence. For example, the coordinator 'and' for the two-part predicate in the sentence cited above was either lost with the string 'gives him a kiss' or else never had any real representation in memory in the first place.

The same phenomenon of grammatical morphemes losing their
existence in conjunction with losses of content units elsewhere in a sentence can be found right through the data. One more example should suffice to illustrate this point.

Sentence 1. Tom and his little brother William are standing at the bus stop with their little brown puppy.

This sentence has three grammatical indicators of plurality, i.e. 'and', 'are' and 'their'. However, as soon as either 'Tom' or 'William' are lost from memory the three markers do not seem to have any representation left in memory at all, as in the case of 'and', or lose the feature of plurality, as with 'are' and 'their'. Subjects who used only one of the two characters in their reconstruction attempts, on questioning, invariably stated that the sentence they had heard or read was something like

Tom (or William) is standing at the bus stop with his (or a) little brown puppy.

and showing no recollection that the sentence was marked grammatically three times for plurality.

It is also interesting to note here that once 'Tom' is lost, not only does the coordinator 'and' have no further independent representation in memory, but that 'his little brother' disappears also, and subjects when questioned merely recall 'William'. Obviously, the subjects' own linguistic knowledge that the noun phrase 'his little brother' cannot be the subject of the opening sentence in a story overrides the strength of any representation that phrase may have had in memory.

We have so far seen that elements of a sentence can remain in or be lost from memory immediately after reading or hearing independently of their serial position in the sentence or the time taken to process it. If we accept the traditional view that STM is a necessary component in a model of memory, that information must necessarily pass through it, that it is a store of limited temporal capacity
and that its contents are phonemic in nature (cf. Table 1, p.15), then we cannot explain why so many subjects in the study could apparently derive completely accurate semantic representation from sentences which by rights should have suffered severe decay effects.

Traditionally STM paradigms have provided a plausible distinction between coding differences in STM and LTM. Coding in STM was variously considered to be acoustical, articulatory, or even visual for so-called 'verbal' material; i.e., words, nonsense syllables, trigrams etc. However, evidence has been presented that this kind of material can also be coded semantically in STM (Shulman, 1972). This appears to remove a useful characteristic which was used to distinguish one store from another. In addition, Shallice and Warrington (1970) have shown that information may not have to pass through STM before entering LTM. It now seems that even the apparent unambiguous evidence from amnesic studies can no longer be interpreted unequivocally in support of a separate STM store (Gruneberg, 1976).

Certainly the case of K.F. first reported by Shallice and Warrington (1970) and other patients discussed by Baddeley (1975) with a similarly impaired digit span, and hence, in the standard view of a dichotomous model of memory, with a severely damaged STM component, throws doubt on the absolute necessity of STM in understanding (and taking part in) ordinary discourse. According to Baddeley, "such patients can carry on a perfectly normal conversation with no evidence of any general memory defect". (1975:160).

A comprehensive case against making a distinction between short and long term stores by bringing together conflicting pieces of evidence from 'verbal' memory studies has been made by Craik and Lockhart (1972). Baddeley (1975) has reviewed additional evidence which argues against the central importance previously accorded to STM and Gruneberg (1976) has reiterated his 1970 criticism of multi-store models of memory, with Jenkins (1974) being particularly
scathing in his attack.

If one is concerned with the processing of natural language, as distinct from 'verbal' material, it pays to be even more cautious and sceptical of the claimed functions and properties of a too narrowly defined, passive STM. Fillenbaum's (1973) claim that people ordinarily can remember the most recently heard sentence 'verbatim' and previously heard ones only as 'gist' is also suspect as anyone can determine for himself by unexpectedly questioning friends and acquaintances in appropriate situations.

Wanner (1974) also seems to have proved in one of his experiments with sentences in connected discourse that any psychological model of comprehension which requires the storage of input stretches of as long as 16 syllables must be wrong, implying that what is processed and stored away at any given time is much shorter than this. Of course, there are many sentences spoken and written daily which are around 16 syllables or longer.

Even staunch advocates of duplex memory models like Shiffrin (see e.g. Atkinson & Shiffrin, 1968) have come to the realization that traditional STM theory does not work satisfactorily any more. While still maintaining that "almost all researchers" currently accept some form of the model that postulates short and long term stores, they nevertheless admit "that it has not proved possible to defend simple models in which STM is a unitary store filled with undifferentiated information that all decays according to a fixed time course" (Shiffrin & Cook, 1978, p.190). This admission is in complete agreement with the results from the present study, but unfortunately, a better model of STM has not yet arrived on the scene, as the following statement shows: "Current models of short-term retention have made only modest forays into the complexities of storage retention and forgetting . . ." (Shiffrin & Cook, 1978, p.190), and the authors are only referring to
memory for verbal material here!

In order to retain a duplex model of memory in which STM retains its prominent position, it may be necessary to start almost from scratch by revising and redefining most of the functions and properties of the old STM enumerated in Table 1 (p.15). It would require building into the model considerable degrees of complexity and flexibility to account for all the accumulated evidence which can no longer be accommodated by the old paradigm. Gruneberg (1976) has rather scornfully dismissed such attempts.

As yet there do not appear to exist fully articulated and tested models of an alternative to the conventional model of STM. However, several writers have proposed new and enlarged roles for a short-term memory component in the total information processing system (e.g., Greeno, 1973; Hitch & Baddeley, 1976). The term 'working memory (WM)' has been used to distinguish the newer conception of a temporary memory component from the conventional limited-storage, restricted-function type of STM. Hitch & Baddeley (1976) assign a general if somewhat limited executive function in information processing to Working Memory as well as giving it a storage capacity which can temporarily hold items while the executive processes others. In terms of sentence processing this would mean that parts of a sentence can be dumped in short-term storage while the processor works on other elements of the same sentence. In the same paper Hitch and Baddeley point out that in their sentence verification task it appeared that process-demands rather than storage demands were responsible for a decline in recall accuracy.

This view is compatible with results from the present study in that the poorer readers generally had far more difficulties with the initial decoding of words (an early stage in processing and a prerequisite for further processing) than the faster readers who were able to sight-
Kieras (1981) has put forward an explicit model of component processes in the comprehension of simple prose. In this model, Working Memory \(^6\) (as distinct from the conventional short-term memory) is seen as having greater storage capacity and fulfilling higher level functions:

> Input sentences are parsed and the results given to the integration process. This process draws upon the results of memory search in Working Memory (WM) and Long-Term Memory to determine what in the sentence is given, that is, already represented in WM, and what is new, not already so represented. . . . Specifications for the new structure are given to the structure builder which adds structure to WM, which thus holds the structure representing the passage content. WM contains semantic network structure like that in LTM and has a moderately large capacity, but its contents are temporary. An encoding process can convert some or all of this structure to permanent structure in LTM, which is the store for general knowledge.

(Kieras, 1981: 2)

A very similar role for WM has been postulated by Just and Carpenter (1980) in their explication of the reading process.

In both the Kieras and the Just & Carpenter models WM interacts constantly with LTM in terms of knowledge, including procedural knowledge for executing or mediating comprehension processes, from controlling eye movements over sentence parsing (Kieras) or case role assignment (Just & Carpenter) to some ultimate long-term memory representation. However, Just and Carpenter rightly stress that while it may be easy to informally agree on such intuitively well-founded structures and processes as they are proposing, it is a different matter altogether to specify their precise characteristics, interrelations and effects on reading performance.

For the present study, models such as proposed by Kieras and Just & Carpenter with their numerous interrelated processes and structures and present indeterminancy could probably be made to accommodate many if not all of the
seemingly random variations encountered in some of the results. Where so many structures and processes interact in a complex and yet little understood fashion it should perhaps not surprise that results are variable for what is after all a fairly heterogeneous collection of subjects trying to comprehend and remember in detail a fairly heterogeneous collection of sentences making up a text.

In contrast to models which retain a clear box-like STM \( \leftrightarrow \) LTM structure, even though the STM component has a much more complex interactive function, there have been proposals which dispense with the distinction between STM and LTM altogether: (e.g., Craik & Lockhart, 1972; Wickelgren, 1973; Gruneberg, 1976). In this view the difference between short-term and long-term forgetting is not a difference in kind but of degree. A single processor attends to incoming information and can be deployed at various levels of processing depth in one of several coding dimensions. The level of processing then determines how well something is remembered.

In the case of sentences, very deep levels of processing can and must be accessed: these make use of previously acquired linguistic rules and pragmatic knowledge of the world to aid in the interpretation and ultimately contribute to a better memory for meaningful sentences. This may be compared with the processing and retention of, say, nonsense syllables, which can only be dealt with at relatively shallow levels of analysis unless subjects in a memory experiment impose their own semantic structure on such material in order to make it more meaningful to themselves.

Essentially, then, the level-of-processing model is based on a memory continuum which, however, at any level of analysis is associated with a memory function termed 'Primary Memory (PM)' (Craik & Lockhart, 1972) which in some ways functions like a kind of working memory that allows continuous recirculation and rehearsal of a small
number of items at any given time. This recycling in itself will not make any contribution to improved memory (this can only be achieved through a deeper level of processing) but the limitations of PM, in particular its restricted attentional capacity, will result in the loss of information if attention must be diverted away from content already in PM. This loss is seen as a function of level of analysis, so that material being processed at a shallow level will be lost rapidly once there is a competing phenomenon making demands on available attention. At the deep end of the continuum, loss will not be as severe as information is dealt with at a deep level of processing.

The theoretical framework for comprehension, remembering and forgetting as sketched out above is an attractive one in its relative simplicity. For the results in the present study it suggests that subjects being sufficiently motivated by the task in hand attempt to process sentences at a deep level of analysis which is aided by their familiarity with the linguistic structure, the common semantic relations and 'everyday' propositions expressed in the individual sentences and the story as a whole. This may be offered towards an explanation of why, even after instances of very slow and disfluent reading, a surprisingly good amount of information was available for recall. It can be further hypothesized that the decrement in performance between slow and fast readers after reading was caused by the slow readers having to devote too much of their attentional capacity to 'sounding out' (decoding) words when compared with the fast readers who were directing a minimum of attention to the task of word decoding, judging from their very fast recognition of most of the words encountered in the story.

The difference in recall becomes more marked the less skilled that children appeared to be at the basic task of word recognition and the more attention they had to give to
'sounding out' individual letters in a word and then having to follow this up with the intense effort involved in 'blending' individually 'sounded' letters into a meaningful word. The OA children and First graders had the greatest difficulties in this regard, and their low level of decoding skills correlates well with the greater number of reconstruction errors made by these children after reading.

A third possibility, in addition to a redefined STM and the level-of-processing approach, is simply to retain the conventional distinction between STM and LTM but acknowledge that STM is not really the crucial component in natural language comprehension it has been made out to be. Baddeley (1976) suggests this possibility in the light of evidence from amnesic patients with grossly impaired STM systems, as measured by digit span tests. These patients seem to be able to carry out normal conversations and exhibit normal long-term learning and recall. The process by which information bypasses STM to receive its direct semantic representation in LTM has been termed 'parallel semantic coding'.

Baddeley (1976) has reviewed the so far rather limited and mainly indirect evidence for this process and arrives at the conclusion that under certain circumstances parallel semantic coding is indeed a possibility. Quoting observations from studies of amnesic patients, Baddeley points out that input rate appears to be a determining factor in whether these patients can cope with incoming information or not. High input rates cause a breakdown in performance as if the amount of information in a sentence is too great to be semantically coded during presentation. For a normal subject this problem does not ordinarily arise, because he has available in STM, probably in phonemic representation, a copy of the incoming information which is accessed when direct semantic processing is not feasible. STM, in this view, is seen as a 'second chance' for normal subjects to process information semantically.
There may be some merit in the idea of parallel semantic coding for the results of the present study. If parallel processing of this nature is accepted as a plausible process in comprehension, then the low reading rates attained by the slow reading subjects could be seen as being conducive rather than detrimental to comprehension. Particularly in the case of the very poor readers the very slow and often disjointed reading of the sentences may nevertheless have allowed sentence fragments direct entry to LTM and hence salvation. Presumably subjects would have to use some sort of reconstructive process based on their linguistic knowledge and knowledge of the world to combine these fragments into full sentential propositions which could then be acted out as a sequence, often with reasonable and sometimes even with perfect accuracy. The fact that the linguistic and pragmatic demands of the comprehension task were well within the capabilities and experiences of all subjects, as demonstrated by the good results from the listening test, would have contributed to the success rate for such a reconstructive process.

Three possible avenues for speculation on memory processes implicated in the comprehension and memory for sentences have been outlined above. They appear to be compatible with at least the general trend of the data obtained in the present study. The data show that slow unskilled readers perform more poorly on a comprehension task after reading relative to their performance of the same kind of task after listening, as well as performing more poorly that their more skilled, faster-reading peers. However, the data also suggests that even though a deficit does exist for the slow readers, it does not appear to be anywhere near the magnitude one might expect if one took literally earlier conventional models of STM which have been used in the reading field to contend that slow reading rates impair or even prevent adequate comprehension. Outlined below is some further evidence which throws doubt upon the contention that sentence processing,
in the sense of comprehending, can only begin at the end of a sentence (or clause) once all its elements have been received into some STM store which keeps them alive while awaiting semantic processing. Rather, the evidence suggests the opposite; i.e., that sentence processing is an on-going task that begins with the first word of a sentence and proceeds at several levels of analysis simultaneously.

Evidence for an interactive, parallel model of sentence processing comes most clearly from several studies by Marslen-Wilson and Tyler (1975, 1976). In the view of these researchers clause boundaries are not important because higher level analysis (comprehension) of accumulated input is delayed until that point, but because it usually is also the boundary of a major unit of meaning and a signal that processing is now complete. This, of course, contrasts with the view expressed by (Jerry) Fodor et al.,(1974) that major processing of a clause is delayed until the boundary of that clause is reached. However, more recently Frazier and Janet Fodor (1978) have proposed a human sentence parsing device which breaks the incoming sentence string into equal-length portions (not unlike a sausage machine) ready for an immediate initial analysis, which will be taken a step further as more information comes in. Frazier and Fodor argue for such a model on psychological grounds (easing the strain on working memory), psycholinguistic grounds (the perceptual complexity of centre-embedded sentences) and the 'short-sightedness' of the parser as evidenced by errors made in initial sentence processing of ambiguous strings. Marslen-Wilson and Tyler have proposed a model of sentence processing in which

from the first word of a normal sentence, the analysis of the input is conducted at all available processing levels. In particular, the information available at any one level of analysis can constrain and facilitate decisions at any other level, so that the continuing phonetic and lexical processing of each word is directly influenced by its current syntactic and semantic context.

(Marslen-Wilson & Tyler, 1975:784)
Since then, after further extensive research, the two writers have firmed up on this position and in their most recent paper (Tyler & Marslen-Wilson, 1981), have summarized their position as follows:

From the first word of an utterance the listener is constructing an 'interpretative' representation of this utterance. This interpretative representation is the outcome of an on-line interaction of linguistic and non-linguistic analyses. That is, listeners are integrating together constraints derived from the specific discourse content, and from their general knowledge of the world, with their linguistic properties of the utterance itself.

(Tyler & Marslen-Wilson, 1881: 401)

This latest in a series of research papers by the two authors appears to be of particular relevance to the present study, as it included a large group (180) of children of comparable age range (5 - 10 years) in the monitoring of sentences (normal, semantically anomalous, scrambled). The results indicate clearly that there were no age-related changes in the basic processes underlying immediate sentence comprehension.

Wanner (1974) also believes that sentence comprehension is an ongoing task and that the hearer processes as much as is necessary of a sentence at any given time to maintain a semantic representation of the sentence as he is receiving it. Other support for the kind of on-line language processing suggested by Tyler and Marslen-Wilson comes from Wold (1977) using experimentally obtained data, and Creider (1978) noting non-verbal features of conversational interaction.

There are several other lines of evidence which support the view that incoming language is processed cumulatively rather than being temporarily kept in storage in a relatively unanalyzed state until a clause boundary is reached. The phenomenon of 'anticipation' that one often encounters in real-life situations is such a piece of evidence. If for some reason a speaker hesitates or speaks very slowly it is often possible for the hearer to 'anticipate' what the speaker is, or was, going to say. If a sentence up to that
point had not been as fully analyzed as possible by the hearer, how would he be able to intelligently predict the speaker's intentions? The same phenomenon can be observed in reading, and Goodman (1973) has gone as far as calling reading a 'psycholinguistic guessing game' in which readers constantly make intelligent guesses as to what is coming next in a sentence they are currently reading and then confirming their hypotheses by sampling the printed symbols on the page. Again, how can one intelligently 'guess' what is coming in a sentence unless one has already 'understood' the previous part(s) of a sentence? The 'cloze' procedure used extensively in comprehension testing is, of course, based on the same principle of 'predicting' what words go into pre-determined empty spaces in a sentence.

In our experiment, the systematic eye movements of subjects while listening to sentences (p.60) can therefore be interpreted as a sign that a sentence was being processed as it was narrated. Similar eye movements can be observed simultaneously in large numbers of people in reaction to only just commenced sentences:

\[ \text{e.g., } \text{Ladies and Gentlemen (eyes turn to the guide)} \]
\[ \text{on your right (eyes turn to the right) you see } \ldots \]
\[ \text{etc.} \]

Finally, the view that sentences (or clauses) must be held in relatively unanalyzed form in some sort of temporary store until it can be fully processed at the end of a sentence (clause) says nothing about the problem of overlap, i.e., when does processing take place if sentences (clauses) follow each other in rapid succession?

If we tentatively accept that the question of memory and comprehension calls for an interactive process in which a single processer operates at several levels of analysis simultaneously right from the beginning of a sentence, it becomes possible to suggest an alternative explanation of the alleged memory deficits of very slow readers compared
with their more fluent counterparts. First, we must consider reading to be a linguistic skill. Like any linguistic skill, or any other highly skilled behaviour for that matter, it can be said to have two sides to it. One consists of the 'mechanics' involved in the skill and the other the ultimate purpose towards which the 'mechanics' are employed. The first component without the second will produce a fairly meaningless, unproductive performance. The second without the first will result in a bad or no performance at all. For example, one can teach a child to make the letter shapes of the alphabet (mechanics), but the child would have to know something about the purpose to which these shapes can be put before he could write a message. For any linguistic, or some other skill, to be developed to a high level of competence the mechanics involved must have been mastered to the level of virtual automaticity. It would be impossible to speak of a famous composer who cannot 'read' music, a soccer star who cannot kick the ball straight, an efficient typist who has trouble finding the right keys on the typewriter, a brilliant actor who constantly fumbles his lines, and so on.

A similar picture can be drawn for reading. If we regard as the purpose of reading the getting of meaning from print, then decoding skills (identification of what the printed symbols are in the first place) are the mechanics.

Slow readers of the kind included in our experiment had problems with decoding skills for various reasons. Some were still beginners (first graders), others because their in and out-of-school experiences with English were limited and had been primarily oral (ESL), and the others could not or had not yet mastered the skills sufficiently (OA and Remedial). 7

However, whatever the reason, these slow, unskilled readers had to divert considerable focal attention to the task of decoding words (mechanics) away from getting at the meaning of what they were reading (purpose).
Hess and Radtke (1981) and Perfetti, Goldman and Hogaboam (1979) have emphasized that in reading attention must be freed for higher level operations and not be unduly taken up by basic lower level decoding requirements. (For a discussion of the importance of attention for information processing generally, see Bransford (1979)).

For the fluent, skilled readers the picture is different. Starting from a slightly better linguistic position (as shown by the listening task) they were able to direct their focal attention during reading towards the meaning-getting process, the lower level process of decoding involving very little focal attention and proceeding virtually automatically. The only really astonishing thing in the performance difference between the slow and fast readers in the study is that the slow readers managed to do as well as they did in the circumstances.

One result in need of some explication in this regard is the fact that the optimum reading rate for good comprehension/retention in this study was around the 2 syllables per second mark rather than faster rates closer to rates observed in normal speech and also in the recording of the listening version of the text. (See Note 8 for a discussion of this point).

One factor which probably contributed towards the relatively good performance of the slow readers, and the excellent performance of the fast readers, was the 'concrete' nature of the sentences involved. It will be remembered that they were so constructed as to allow the physical 'acting-out' of their content. Studies, e.g. those by Davies and Proctor (1976), and Holmes and Langford (1976) have shown that, everything being equal, 'concrete' sentences are understood and remembered better than 'abstract' ones.

Recently, Smith (1981) has found that memory for sentences in adults was superior when sentences were concrete rather than abstract, provided the sentences were also affirmative.
In the present study all sentences could be said to be concrete as part of the requirement that they had to be acted out. Further, in both the reading and listening versions of the story all sentences with one exception were in the affirmative mood.

In experiments with children, Rusted and Coltheard (1979) have shown that pictures play a significant role in the enhancement of children's memory for whole prose passages. While the present study did not include a visual presentation of episodes from the story, the properties used in the reconstruction phase of the experiment were readily observable during the listening task. For both the listening and reading tasks the acting out of each sentence and the visual representation of a scene which remained after each acting-out of a sentence may well have been important factors in establishing more firmly in the subjects' memory the pertaining discourse relations and the bearing they had on the unfolding of the story and the ultimate comprehension of each sentence as a function of the story context.

Explanations for differences in the retention of abstract versus concrete material have been proposed in terms of the 'dual coding hypothesis' (Paivo, 1971). Essentially, the hypothesis claims that verbal and non-verbal information are processed in functionally independent though interconnected systems, which allows verbal information to be transformed into non-verbal information (images) and vice-versa. The hypothesis also states that concrete objects and objects with physical referents, e.g., concrete sentences, are coded both verbally and visually with the attendant prediction that such sentences are recalled better than abstract ones which do not lend themselves to imagery. Paivo (1971) contains an extensive review of the data in support of the beneficial effect of imagery on recall.

Merry and Graham (1978) have suggested, in addition, that 'bizarre' images (e.g., one representing a sentence like
'The hen smoked a cigar') produce better recall in children of words from 'bizarre' sentences. While it is not suggested that the present study contained bizarre image-producing sentences it can nevertheless be suggested that most sentences and the story content itself were sufficiently vivid and at the same time close enough to the children's more exciting every-day experiences to produce a sufficiently high level of arousal to support the imaging process.

Returning to the assertion that comprehension of sentences as part of a natural language discourse content, such as is represented by the reading of a story, must necessarily suffer because allowed processing time has been exceeded has been shown to be difficult to maintain. The fact that sentences can be understood even though the capacity of STM has been exceeded by several times its stated limits weakens the case for a STM as originally conceived and since popularized in fields outside psychology. The conventional type of STM would need to be replaced by a more complex working-type memory that takes a very active part in the interpretation of sentences as they are in consciousness. Alternatively, there may be no need for a dual memory at all, or, the previously postulated dependence on STM as an essential stage in information processing may not be true and that semantic interpretation and integration can be achieved under favourable circumstances by by-passing STM altogether.

As to sentence processing generally, leaving open the question of how many memories and their exact specification, the writer favours the following explanation which is in part supported by, or at least compatible with, results from the present study.

In this explanation, a processor begins work on incoming sentences as soon as the beginning of an utterance is perceived. This analysis can and does proceed at various levels of linguistic analysis, including the semantic one, simultaneously and involves an on-going process of predicting, verifying or codifying units of analysis in
the light of new incoming information. Good support for the view that active and effective monitoring, resulting in the rejection and replacement of erroneous units of analysis, does take place comes from the observation that despite the large number of corrections many sentences underwent during reading (p. 58), these sentences were always demonstrated in terms of the correct rather than the incorrect reading, although the misreadings were syntactically and semantically acceptable, and must, at one stage, have had some kind of representational status in some kind of memory.

A sentence in this alternative model of sentence processing is virtually comprehended as soon as the last word is heard. All that remains is what Just and Carpenter (1980) have called 'sentence wrap-up' involving the construction of interclause relations and an attempt at reconciling any inconsistencies which could not be resolved within the sentence. 'Comprehension' as such probably consists of deriving some kind of semantic representation, or even a unitary mental image, rather than a verbatim copy of a sentence. Where a verbatim copy of the last heard clause or sentence is available, this may be more the result of what the particular recall task required than the automatic result of ordinary processing. If subjects are aware that they are going to be tested on the verbatim recall of sentences, they are likely to try to retain as many details as possible of the original sentence form together with the representation they would ordinarily be satisfied with.

That this may indeed be so has been shown by Anderson (1974) and Marslen-Wilson and Tyler (1976) who found that both perceptual (verbatim) representations and propositional (semantic) representations are available immediately after the reception of sentences. However, five-year-old children in the Marslen-Wilson and Tyler study showed little evidence of retaining lower level information but could integrate a sentence automatically just as rapidly as adults. Evidence
of this sort does seem to further weaken the need for a short-term and long-term memory distinction for sentence processing. The last major objection that may be raised in support of the necessity of STM in the comprehension of sentences is the result that long sentences produced the largest number of errors for both slow and fast readers. If STM is not crucial as far as the time course of sentence processing is concerned, at least the overload factor, i.e., too many items in a limited space, remains a logical explanation. Are very long sentences necessarily harder to understand than short ones? Perhaps this is only a matter of recall here. If that is the case, poorer performance on long sentences is not a matter of comprehension but of memory and not so different from the likelihood that the details of a short story are better recalled than the details of a very long one. In other words, memory and comprehension can be quite independent of each other. One can understand something very well without necessarily being able to recall all that much of it afterwards, particularly the details. Similarly, if one is so inclined or required, one can memorize something with little or no understanding involved. Whether the longer sentences in the story were harder to understand or whether they were more difficult to recall from memory in toto remains open to speculation.

The latter explanation appears to be more reasonable, considering the kind of errors that were made on these sentences. While there were some examples of real misunderstanding, most errors did not affect the meaning of a sentence substantially, and all subjects were quite able to follow the story line from beginning to end across the various sentence boundaries without great difficulties, indicating that the main propositional content of the sentences had been understood and semantically integrated.

In conclusion it may be said that the study has not produced any real supportive evidence for a distinction between
conventional short-term and long-term memory stores and the central role the short-term store is believed to play in the processing of natural language units like the sentence. The results which could be quoted in support of STM can be explained equally well in another framework.

Earlier models of memory, now recognized within psychology as being inadequate, but still being quoted elsewhere, are unlikely to be of much value in explaining how natural language is processed and what factors govern the remembering and forgetting of sentences in real-life situations. Certainly the nature of the task, the total text, the meaningfulness of the individual sentence and the salience of particular elements within it; the motivation, cognitive abilities and associated skills of the individual person, and other aspects of the total context of situation contribute to the quality of the event where a person is engaged in understanding and remembering a sentence.

If there are any practical implications to be found in the results from the present study they may be these:

- slow reading does not necessarily produce poor comprehension. Hence, while fluent reading is a desirable goal, it does not appear crucial to satisfactory comprehension:

- if remembering is the main objective in reading, shorter sentences may have the advantage over longer sentences (as probably shorter stories have over longer ones):

- sentences and stories which have a high degree of 'concreteness' and hence imagery value built into them may be more easily remembered than more 'abstract' ones.

Finally, the following admission must be made. While the study took as a starting point the assumption 'no memory - no comprehension' it is possible to look at the relationship
from the opposite point of view. In real life people attempt to comprehend sentences rather than remember them, and whatever remembering eventuates may be regarded as the product of understanding. Even though the study set out to investigate the importance, or otherwise, of a certain kind of memory to comprehension, it must be recognized that the design does not allow a clear and unambiguous interpretation of results. That is, the question of whether any of the children's responses, whether right or wrong in terms of the design, were the consequence of memory acting on comprehension or vice versa cannot be unequivocally answered here.
1. Chafe (1973) made an attempt to link certain aspects of (English) language structure and usage to features of a multi-store model of memory. He has since abandoned this line of inquiry (personal communication).

2. Notwithstanding the tentative result that certain broad grammatical categories may be more subject to loss or incorrect retention than others (cf. Chapter IV).

3. I have recently observed a large number of children in this age range attending 'Learn-to-swim' classes with a parent. Very few mothers, and then only rarely, and none of the fathers was observed in addressing their sons with 'darling', 'sweetheart' or similar terms of endearment. However, many more girls were addressed this way quite frequently, including some by their fathers.

4. People engaged in ordinary conversation or listening to a narrative usually cannot reproduce verbatim the last heard sentence (unless it is very short) if no previous warning has been given. This emerged from the writer's testing of about two dozen people informally on this task.

5. Gruneberg refers to these as:

   attempts by those still holding a dichotomy to patch up a torpedoed vessel with chewing gum. Only a super optimist would sail on such a vessel in the belief that such a voyage might generate new ideas. To my mind one is more likely to be so preoccupied with keeping the vessel afloat to notice even that the sun is shining.

   (Gruneberg, 1976:333)

5a. Anybody who is not convinced that the lack of lower-level reading skills, such as decoding (identifying) printed symbols, can have a marked effect on comprehension should apply his reading skills to this simple English message written in an uncommon script.
6. According to Kieras (1981) there seems to be no agreement yet as to the consistent use of the term. While some use it to draw attention to essential differences others use it as if it were an alternative to short-term memory as originally conceived.

7. The significance of the ANOVA results (Chapter IV, p.43) is that performance suffered in line with predictions which could be made for each subgroup of slow readers. The normal remedial readers performed best and were not very far behind their faster-reading peers because of their previous experience with reading (average age for this group was 8.8 years and this was their fourth year at school). Next came the ESL readers (average age 8.4 years and experience with reading English prose unknown), also a normal group of subjects except for their second language background. Their experience with reading English prose must have been somewhat less even if only judged by the heavy audio-lingual emphasis in their classroom instruction. Then came the normally developing first graders (average age 6.8) where reading experience to that point had not been sufficient to develop a large sight vocabulary or efficient decoding strategies. Last came the children who because of learning difficulties (including reading) and assessed I.Q. have been put into a special class. There was little evidence of written language playing a significant part in their classroom instruction.

8. It is not clear why a reading rate of about 2 syllables/second produced the best results. However, the results are compatible with those reported by Riding and Shore (see Chap.III, p. 29) where a test passage read at slightly less than two syllables per second produced the best comprehension for low I.Q. children.

The result may also be looked at in the light of the articulation rates employed by the five teachers in preparing the listening version of the text. While the average rate was 3.38 syllables/second this hides the fact that the ESL teacher read much more slowly (2.7 syllables/second) than the others. A slower speech rate is one of the characteristics of 'foreigner talk', i.e., the speech of native speakers to unskilled non-native speakers of a language. However, it seems an inherent feature of foreign language comprehension that the novice not knowing what to listen for in the stream of language, in order to distinguish the important cues from the less important cues, must try to attend to every bit of an utterance with equal intensity. A slow input will obviously be of great help in the process.

Similarly, slow but careful reading (not hampered by decoding difficulties) of a sentence will allow a reader to give careful and equal attention to all its elements with the result of the sentence having a greater chance of being recalled with all its details present. Of course, this was exactly the type
of recall the experimental task asked for. On the other hand, some of the faster readers may have sacrificed some of their attention to detail by not adjusting their normal reading rate in their natural drive to get at the significance of what they were reading.

9. The only negative, and in a certain sense 'abstract' sentence was No. 13 in the reading version (The skinny man didn't hide.). This sentence produced reconstruction errors from six of the slower readers. This may be compared with sentence No. 9 (Dad is behind the house.) of approximately equal length and high 'concreteness', which produced only one error (see Appendix F).

10. One modern method of foreign language teaching (TPR = Total Physical Response) has as its main methodological cornerstone the acting-out of verbal material. Very good results have been claimed for this method (e.g., Asher, 1977).

11. However, imagery is said to be affected by the mode of presentation with visual material having a suppressing effect on it. It has been suggested that this effect could be implicated in the result that verbs appeared to have greater salience after listening and that subjects after reading were less inclined to embellish their responses with extraneous ideas (O. Katchan, personal communication).

12. There are, of course, a number of factors which may hinder or prevent comprehension of a sentence; e.g., if it contains material beyond the cognitive and linguistic level of the receiver.

13. There may be a case for longer sentences of a certain structural description to be harder to understand than others of equal length but different structure. The classic example is centre-embedded sentences of the following kind:

   This is the girl, that the boy, whom the woman, which the man saw, knows, loves.

where the lexical items and pragmatics of the context do not offer any clues to a semantic interpretation. A sentence with multiple embedding can be made very long, as some children's poems illustrate, without causing any comprehension problems. Right branching embeddings as in the well-known "This is the house that Jack built" are easy to follow and comprehend.

Sentence complexity, then, may interfere with the comprehension if the receiver has no command over the structure as in the case of adults with centre-embedded sentences or in the case of very young children and foreign learners of a language. Sentence complexity was not a variable in the study, but it was judged that all structures had been fairly well mastered by all subjects. There was no evidence that any particular structure(s) caused subjects to misinterpret or fail to understand a sentence completely.
Since the reconstruction phase of the experiment, particularly for the reading version, took place outside stated temporal STM limits and since it is assumed that no rehearsals took place, it must be acknowledged that errors in reconstruction as well as correct responses must be regarded, at least partly, as measures of Long-Term Memory (see Baddeley, 1976). Alternatively they may be seen as retrievals from 'episodic' memory which is considered as a time-ordered series of memory traces of specific events with the most recent in the series being most likely to be accurately recalled. For a discussion of this memory for specific events as distinct from 'semantic' memory, our general, more permanent store of general knowledge about the world, see Reynolds & Flagg (1977).
BIBLIOGRAPHY


Watts, B., McGrath, W. & Tandy, J. (1972). Bilingual Education in Aboriginal Communities, Canberra, Department of Education.


ADDITIONAL REFERENCES


APPENDIX 'A'

'Make a Story'
(Text only of experimental materials used)

Practice Passage

1) Peter is walking home from school.
2) Suddenly, a dog jumps from behind a car and chases Peter.
3) He jumps over a garden fence and starts crying.
4) The dog is barking.
5) A car comes and stops in front of the fence and a man gets out.
6) He kicks the dog and tells him to go away.
7) The dog runs away.
8) Peter jumps back over the fence and says to the man, "Gee, thanks a lot, Dad."
9) Then Peter and his father drive home together.

Story Version 'A' (Listening)

1) John and his little sister Patricia are walking to the shops with their little white dog.
2) Near the church they see two big boys and a very fat man playing with a football.
3) John kicks the ball behind a car that is standing in front of the supermarket, and the little dog runs after it.
4) The boy in the red shirt says, "Why did you kick our ball?"
5) He gives John a push, and John falls down.
6) His little sister is crying now.
7) She runs home and tells her mother that a bad boy has pushed John.
8) Her mother gives her a kiss and says, "Don't cry, sweetheart."
9) Dad is in the garden.
10) He runs to John.
11) Mother and Patricia go to him, too.
12) The two boys hide behind the milkman's truck when they see John's father.
13) The fat man does nothing.
14) Behind the truck there is a big black dog who bites one of the boys on the leg.
15) They run back to John and tell him that they are sorry.
16) John jumps up.
17) He says, "Good, I want to be friends with you."
18) The little dog comes back with the ball.
19) After that all the children and the small dog go into the park behind the shops and play with the ball.
20) John and Patricia's parents go to do the shopping.
21) Then they go home.
22) The fat man and the black dog go away, too.

Story Version 'B' (Reading)

1) Tom and his little brother William are standing at the bus stop with their little brown puppy.
2) Near the school they see two big boys and a very skinny man playing with a red ball.
3) Tom kicks the ball behind a tree that is standing next to the post office, and his little brother runs after it.
4) The boy in the blue pants says, "Where did you kick my ball?"
5) He gives Tom a kick, and Tom runs away.
6) The little puppy is barking now.
7) William runs home and tells his mother that a big boy has kicked Tom.
8) His mother gives him a kiss and says, "Don't worry, darling."
9) Dad is behind the house.
10) He runs to the boys.
11) Mother and William go to them, too.
12) The two boys hide behind the school bus when they see Tom's father.
13) The skinny man doesn't hide.
14) Behind the bus there is a big yellow dog who bites one of the boys on the arm.
15) They run back to Dad and tell him that they are sorry.
16) Tom comes back.
17) He says, "Good, I want to play football with you."
18) The little puppy brings back the ball.
19) After that all the boys and the skinny man go into the playground behind the school and play with the ball.
20) Tom and William's mother goes to do the shopping.
21) And Dad goes home.
22) The big dog and the little puppy go away, too.
APPENDIX 'B'

Lay-out of experiment for reading (for listening the lay-out was similar but use of a tape-recorder instead of a book and a different arrangement and selection of cut-outs).

Recording equipment concealed in desk.
### APPENDIX 'C'

Weighted Scale for the Assessment of Errors in the Reconstruction of Sentences After Reading and Listening

#### 1. Phrase Level Errors

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Example</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) substitution of optional element</td>
<td><em>e.g.</em>, little brown puppy $\rightarrow$ little white puppy</td>
<td>4</td>
</tr>
<tr>
<td>b) loss of optional element</td>
<td><em>e.g.</em>, a red ball $\rightarrow$ a ball</td>
<td>1</td>
</tr>
<tr>
<td>c) substitution/loss of obligatory element</td>
<td><em>e.g.</em>, a very fat man $\rightarrow$ a very fat boy</td>
<td>1½</td>
</tr>
</tbody>
</table>

#### 2. Clause Level Errors

<table>
<thead>
<tr>
<th>Error Type</th>
<th>Example</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) substitution of optional element</td>
<td><em>e.g.</em>, Near the church $\rightarrow$ In the park</td>
<td>1</td>
</tr>
<tr>
<td>b) partial loss of optional element</td>
<td><em>e.g.</em>, ... kicks the ball behind a tree that is standing next to the post office $\rightarrow$ ... kicks the ball next to the post office</td>
<td>1½</td>
</tr>
<tr>
<td>c) complete loss of optional element</td>
<td><em>e.g.</em>, ... who bites him on the arm $\rightarrow$ who ites him</td>
<td>1</td>
</tr>
<tr>
<td>d) substitution/loss of obligatory element</td>
<td><em>e.g.</em>, He gives Tom a kick and Tom runs away $\rightarrow$ He gives Tom a kick and runs away.</td>
<td>3</td>
</tr>
</tbody>
</table>

**NOTE:** For the loss of one member in the case of a pair of conjoined phrases the score was halved.
# APPENDIX 'D'

Table of subjects/sentences scored for Sign Test following application of weighted scale (see Appendix 'C')

<table>
<thead>
<tr>
<th>Subjects</th>
<th>Remedial</th>
<th>First Graders</th>
<th>OA Pupils</th>
<th>ESL Pupils</th>
<th>Skilled Readers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1  2  3  4  5  6  7  8  9</td>
<td>10 11 12 13 14 15 16 17 18</td>
<td>19 20 21 22</td>
<td>23 24 25 26 27</td>
<td>28 29 30 31 32 33 34 35 36</td>
</tr>
<tr>
<td></td>
<td>41 42 43 44 45 46 47 48 49 50</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- : Inferior reconstruction of sentence after reading.
- : Inferior reconstruction of sentence after listening
0 : No difference

* \( P < .05 \)
** \( P < .01 \)
APPENDIX 'E'

Summary tables of 2-way ANOVA split-plot factorial design using unweighted means solution for unequal numbers of subjects.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reading Ability (A)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>140.031</td>
<td>1</td>
<td>140.031</td>
<td>19.645</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>b</td>
<td>10.88</td>
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<td>10.88</td>
<td>3.362</td>
<td>p &lt; .1</td>
</tr>
<tr>
<td>c</td>
<td>171.734</td>
<td>1</td>
<td>171.734</td>
<td>44.653</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>d</td>
<td>143.131</td>
<td>1</td>
<td>143.131</td>
<td>54.443</td>
<td>p &lt; .001</td>
</tr>
<tr>
<td>e</td>
<td>52.243</td>
<td>1</td>
<td>52.243</td>
<td>13.031</td>
<td>p &lt; .005</td>
</tr>
<tr>
<td><strong>Subj. w groups</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a</td>
<td>342.123</td>
<td>48</td>
<td>7.128</td>
<td></td>
<td></td>
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<tr>
<td>b</td>
<td>67.957</td>
<td>21</td>
<td>3.236</td>
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<td></td>
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<tr>
<td>c</td>
<td>96.14</td>
<td>25</td>
<td>3.846</td>
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<td></td>
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<tr>
<td>d</td>
<td>44.679</td>
<td>17</td>
<td>2.629</td>
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</tr>
<tr>
<td>e</td>
<td>84.179</td>
<td>21</td>
<td>4.009</td>
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<tr>
<td><strong>Task Modality (B)</strong></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>a</td>
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<td>31.112</td>
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<td>22.418</td>
<td>13.305</td>
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</tr>
<tr>
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<td>1</td>
<td>69.109</td>
<td>22.96</td>
<td>p &lt; .001</td>
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<tr>
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<td>50.884</td>
<td>20.701</td>
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</tr>
<tr>
<td><strong>Interaction A/B</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>a</td>
<td>56.791</td>
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<td>56.791</td>
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<tr>
<td><strong>B x subj.w groups</strong></td>
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<tr>
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<td>b</td>
<td>35.384</td>
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<td>1.685</td>
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<td>c</td>
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<td>d</td>
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<td>2.458</td>
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a = values for all subjects (n = 50)
b = values for remedial and skilled readers (n = 23)
c = values for 1st graders and skilled readers (n = 27)
d = values for OA pupils and skilled readers (n = 19)
e = values for ESL pupils and skilled readers (n = 23)
# A P P E N D I X ' F '

Reading times in seconds for correctly/incorrectly
retained sentences per subject

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| ESL Pupils | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 |
| Top Reading Group | 71 | 97 | 14 | 50 | 37 | 35 | 44 | 25 | 15 | 22 | 19 | 32 | 46 | 26 | 40 | 33 | 41 | 43 | 55 | 57 | 60 | 77 |

| sentence correct, reading time ≥30 seconds |
| sentence incorrect, reading time ≥30 seconds |
| sentence incorrect, reading time <30 seconds |
**APPENDIX 'G'**

**Total number of sentences with errors in reconstruction after Reading (R) and Listening for all Subjects (S)**

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