The Ageing Game: Neural Plasticity, Cognitive Training, and Transfer of Training Gains to Everyday Activities for Older Australians

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Declaration

This thesis contains original research undertaken during the Doctor of Philosophy (Clinical Psychology) in the Research School of Psychology at the Australian National University. I hereby declare that this thesis is a culmination of my own original work, apart from the usual contributions of my supervisors, Prof. Kristen Pammer, Dr Jay Brinker and Dr Vanessa Beanland. To the best of my knowledge, no material previously published or written by any other person is included, except where due acknowledgement is given.

Iris Elizabeth Carter

Dedication

I would like to dedicate this work to two key people in my life. Firstly, to my husband Dale Hughes who had no idea what he was getting into when he asked me to marry him. He thought he was getting an academically and commercially well-established wife who would continue to remain in her chosen field for the rest of her working life. What he got was a wife who was totally dissatisfied with her career and who threw it all in and went back to university – in a field where none of her previous studies were relevant. That meant that my dear husband Dale went from an equal economic and workload partner to one who had to earn the money while I did my undergraduate studies and then support me emotionally and in practical ways for the whole of my new academic and career life. Thank you.

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Services of a professional editor, Ms Elizabeth Bird, were engaged to assist in the preparation of this thesis for submission. Ms Bird provided those services in accordance with the Australian standards for editing practice and were restricted to Standard D: Language and Illustration, and Standard E: Completeness and Consistency. I am very grateful to Elizabeth for her professional services and her kind encouragement.

Abstract

Healthy ageing is important for individuals, families, and the economy. The ability to remain independent, care for oneself, and engage in social activities remains a key element to avoid social isolation, depression, and associated health decline. Later life changes in neural processing speed and attentional processes are among the changes associated with normal, healthy ageing, but these changes are often the harbinger of loss of confidence and ability in other more complex activities related to living independently in the community. Cognitive training has shown some promising, but inconsistent results in compensating for cognitive performance losses. Although cognitive training results in improved performance on a trained task, there is mixed evidence of transfer of training gains to other close related (near-transfer) or more distant (far-transfer) cognitive functions. This research aimed to examine the importance of attention as a key component of cognitive training and its contribution to the transfer of training gains. The far-transfer target was the UFOV Test which served as a proxy for driving, an important element of independence for older people. Fifty community-dwelling older adults attended lab-based sessions where they completed the UFOV tasks pre- and post-intervention. The intervention was attention-targeted training or working memory-targeted training that was accessed via a purpose-built website, in their homes on their own computers. Due to the repeated measures design, and that group results were compared across intervention type and a no-intervention control period, multilevel linear modelling was used for analysis. Additionally, individual differences were examined to identify predictors of UFOV performance. Results of the UFOV Processing Speed task showed substantial ceiling effects indicating no room for improvement on this task from the

intervention. A clear transfer of training gains from the home-based cognitive training to the UFOV Divided Attention task was demonstrated, supporting the success of training transfer to an unpractised task. However, there were also transfer gains for the Working Memory group (unexpected, but interesting). Results for the third and most difficult of the three UFOV tasks targeting selective attention indicated a strong practice effect that obscured any benefits from home-based training. Examination of individual differences identified fluid intelligence/attentional control significantly predicted UFOV performance and that insight into lapses of attention declines in older age. Although this research produced mixed results, it did demonstrate that home-based cognitive training resulted in far-transfer to a proxy for driving competence in a group of older adults. These results contribute to evidence for training-related cognitive gains for older adults, with emphasis on attention training. The uptake and adherence to the training program by participants confirmed the benefit of supporting older people to train at home rather than at a university-based lab. The importance of this finding is that offering easily accessible cognitive training, at a time convenient to the individual and in their own home, provided the opportunity for older people to engage in activities that may assist in maintaining independence and wellbeing.

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The proportion of the population reaching retirement age has been steadily increasing. In 1950, the proportion of those aged 60 and over was 8%. Today that proportion has risen to 24% and is expected to reach 35% in 2050 (United Nations, 2017). Further, in 2019, 1 in 11 people were aged over 65 years and that is expected to increase to 1 in 6 by 2050. In 2018, for the first time in history, the number of people 65 years and older outnumbered children under five years across the world (United Nations, 2019). At present, life expectancy from birth for those born in Australia and New Zealand is currently estimated to be 83 years (United Nations, 2019), however according to the 2021 Census, 17.2% of the Australian population was aged 65 and over (Australian Bureau of Statistics, 2021). These statistics indicate the success of endeavours to increase longevity, even so the true measure of this success should be the quality of the extended life (McInnes, 2011).

Successful ageing is a term used to summarise the effects of avoidance of disease and disability, maintaining effective physical, cognitive and psychological functioning, and ongoing participation in active social engagement throughout the later years of life (Depp, Vahia, & Jeste, 2010; Reichstadt, Depp, Palinkas, Folsom, & Jeste, 2007; John W. Rowe & Kahn, 1987; Von Faber et al., 2001). A sense of control over the ageing experience, a positive view of ageing, and seeing opportunity in retirement has been identified as potentially leading to a willingness to engage in new experiences and adventure (Yates, Perry, Onyx, & Levett-Jones, 2021) as well as reduce the risk of cognitive decline (Yao, Luo, Wu, Gao, & Sun, 2023). For example, the phenomenon of Grey Nomads has quietly emerged over the last 20 years where retirees take to the roads in rural Australia to explore, seek new experiences and meet new people, with the unexpected flow-on of increased physical and mental health (Yates et al., 2021). Reichstadt et al. (2007) asked a cohort of adults aged 60 to 99 years to describe what they believed contributed to successful ageing. The most frequent items cited were being able to *engage in meaningful activity* and *social stimulation,* but in the oldest old (over 85 years; Australian Bureau of Statistics, 1999), being able to adapt to changes associated with ageing was what best maintained their wellbeing (Von Faber et al., 2001). In the absence of meaningful activity, stimulation and social engagement, ageing has been reported as leading to isolation, boredom, depression, and significant cognitive decline (Depp et al., 2010; Piccirilli, Pigliautile, Arcelli, Baratta, & Ferretti, 2019).

Another element identified as important for successful ageing was the maintenance of independence and the ability to care for oneself in the greatest capacity possible (Kaspar, Wahl, Diehl, & Zank, 2022; Motamed-Jahromi & Kaveh, 2020). Independence relies strongly on the ability to care and do for oneself in areas such as: shopping; managing medications and personal finances; housekeeping; and being able to make use of personal and/or public transport (Gobbens, 2018; Hambisa, Dolja-Gore, & Byles, 2022). These activities, and those required for social interaction all require the cognitive ability to focus and engage. For example, shopping involves repeatedly searching for the desired item in a vast array of products on numerous shelves, managing medication requires vigilance and concentration to ensure correct dosage and timing, and making use of transport is either being able to drive oneself or negotiating public transport. Loss of independence frequently leads to reliance on a carer or admission to institutional care (Gallucci et al., 2011), both of which significantly increases the risk of social isolation, depression, and further cognitive decline (Vaismoradi, Wang, Turunen, &

Bondas, 2016; Walker & Paliadelis, 2016). For ageing adults, the loss of access to activities associated with social connectedness and independence potentially leads to social isolation, lowered well-being, increased depression, and stress (Dahan-Oliel, Gelinas, & Mazer, 2008; Ettema, Garling, Olsson, & Friman, 2010; Gagliardi, Marcellini, Papa, Giuli, & Mollenkopf, 2010).

Therefore, to preserve independence, being able to engage in meaningful activity and to maintain social relationships requires functional cognitive abilities. The cornerstone of all cognitive abilities is attention.

What is Attention?

> *Everyone knows what attention is. It is the taking possession of the mind, in clear and vivid form, of one out of what seem several simultaneous possible objects or trains of thought. Focalisation, concentration of consciousness are of its essence. It implies withdrawal from some things in order to deal effectively with others.* (James, 1890/1976, pp. 404-405)

As this notable quote from the philosopher and early psychologist William James suggests, attention is a cognitive process that enables the sifting and sorting between stimuli of importance or interest, and other stimuli that must be ignored or supressed to make way for the selected stimulus. Of note, this description also encapsulates the effortful nature of attention along with the notion that attention is a selective process, recognising that real-world functioning requires an enormous amount of cognitive effort in terms of filtering the environment for relevance and selectively attending to important items. This definition implies the intrinsic overriding character of attention; that attention may be directed or captured, depending on the goals and/or urgency of the task or situation. In essence, attention is a cognitive function critical for monitoring and engaging in the environment.

As observers' ability to process and report multiple stimuli from a visual viewpoint is limited (Chun & Potter, 1995), a mechanism that ensures we are directed to relevant and/or important information is crucial to efficient information gathering and ultimately, our survival. Visual attention provides this mechanism and is controlled by both top-down (cognitive) factors, such as knowledge and expectation, and bottom-up (sensory) factors which are generally stimulus driven. For example, unexpected, novel, or salient events would automatically be interpreted as potentially dangerous (Corbetta & Shulman, 2002), and these stimuli would burst into our awareness and override other cognitive events in progress at the time. In order to accomplish these feats of prioritising for survival, attention acts like a buffer, which captures and gates competing inputs, and then makes a selection for further processing into short-term memory (Broadbent, 1958). For example, while navigating through an unfamiliar city we are alert to red and green traffic lights, because they are important for the navigation process (knowledge and expectation), whilst red and green lights in another context (such as neon lights) are passed over quickly and ignored. However, a child running beside the road quickly overrides our attention and diverts it to the source of the potential driving threat (unexpected, salient and potentially dangerous; Pammer, Bairnsfather, Burns, & Hellsing, 2015).

Attentional Selection

Early theories of attention focused on why some stimuli gained selection over others, and the processes involved in such selection (Duncan, 1980; Treisman & Geffen, 1967; Treisman & Gelade, 1980; Wolff, 1998; Steven Yantis & Jonides, 1984). Broadbent (1958) first proposed that overt identification of an item was the result of gating and selection processes, which occurred early in the attention process and were primarily based on gross physical characteristics. According to this early-selection hypothesis, once an item failed selection by attention (e.g., the irrelevant neon lights), it was rejected, and no further processing occurred. However, following evidence that suggested irrelevant stimuli were processed to some degree, Deutsch and Deutsch (1963) proposed an alternate model where unlimited, involuntary and simultaneous attentional processing occurs, accessing all sensory inputs, but a limitation arises when some kind of action or response is required. The Deutsch and Deutsch (1963) theory included idea of a buffer or bottleneck as proposed by Broadbent (1958) but placed the filter late in processing, *after* significant analysis had been carried out. Later theories concluded that the initial attentional analysis was detailed enough to result in at least the identity of the sensory event, which then fed into a later, more selective stage (Broadbent & Broadbent, 1987; Duncan, 1980). Although debate continues, the generally accepted view that emerged from these early theories is that feature and semantic processing of all stimuli occurs during an initial perceptual process, followed by a selective process where an item is either selected for further processing into short-term memory, or is rejected (Chun & Potter, 1995; Olivers & Meeter, 2008).

During top-down processing, categorisation into irrelevant information (reject) and selection of relevant information, relies on attention being able to correctly classify stimuli so a template, or attentional set, of relevant features, category, and/or meaning is created and maintained in working memory. Then, all attended items are compared to the attentional set and if an item does not match, it is classified as irrelevant and inhibited. Thus, the attentional set provides a mechanism for the prioritisation and extraction of relevant over irrelevant information

(Broadbent & Broadbent, 1987; Corbetta & Shulman, 2002; de Fockert, Rees, Frith, & Lavie, 2001; Olivers & Meeter, 2008; Potter, 1976). Because the sensory environment is constantly bombarded with information over and above that which is important to current goals, managing distractions and maintaining focus is also reliant on the attentional set. Attentional inhibition blocks out unnecessary stimuli which allows for effective emphasis on relevant information (Lahar, Isaak, & McArthur, 2001; Newman & DeSchepper, 1991). Although the general consensus is that attentional set is a unitary process, the functions of active selection and maintaining focus are seen as two different cognitive functions by some authors (Andres, Guerrini, Phillips, & Perfect, 2008; Friedman & Miyake, 2004; Nigg, 2000).

Visual and attentional selection has traditionally been studied using a vast range of psychological behavioural methods. Some of the more common methods include visual search, dual task, rapid serial visual presentation (RSVP), and negative priming. In a dual task paradigm, participants must perform two attention-based tasks to compare performance with a single-task condition. An example is having to track a moving object while locating a fixed object – the tasks are performed simultaneously and separately for comparison (Wahn & König, 2015). In RSVP (Raymond, Shapiro, & Arnell, 1992), two targets are presented, with a temporal gap in a stream of visual distractors. The presentation is rapid and sequential, and the objective is that the observer identifies both targets. However, depending on the number of items between the two targets, the second target is frequently missed; a paradigm called the attentional blink, and the attentional blink has been used extensively to measure the temporal limitations of attention. Effective inhibitory processes are important to prevent interference from irrelevant or unimportant distractions while focused on a task. Negative priming tasks can determine the efficacy of such selection processes via the participant's ability to resist a salient distractor previously identified as a target in an earlier trial. Slowed reaction times compared to that of novel stimuli, indicate the discrepancy in certainty around the response and provide a measure of selective attention (Milliken, Merikle, Joordens, & Seiffert, 1998). Visual search tasks generally require the observer to identify a target among multiple non-targets, or distractors. Because visual search tasks are common in both research and the real world, they are discussed in more detail below.

Searching the Environment

Most visual search tasks require visual attention. The environment is naturally cluttered and cannot be processed all at once; therefore, attention is required to direct and control the manner of search for an object, group of objects, or location. The most prominent theories of visual search are feature integration theory (Treisman & Gelade, 1980) and guided search (Wolfe, Cave, & Franzel, 1989). Feature integration theory categorises visual search into two stages (preattentive and focused); a limited preattention process which is fast and largely unaffected by distractors. Directing this search are basic, single features such as colour, size and orientation. For example, when searching for a friend in the crowd who is wearing a yellow hat, an observer searches for yellow, and the yellow hat appears to pop out of the mess of colour and shapes in the crowd. Treisman nominated this kind of search as parallel because large chunks of the visual field can be processed at once. Parallel search is inherently efficient, and the timing of the target search is generally unimpaired by the number of distractors (non-yellow objects). This is supported with reaction time results for such searches producing a flat function regardless of the number of distractors in the search. Thus, when an observer is required to detect a single feature in an array, early perceptual processing is sufficient for identification, such that pop-out occurs, and attention is only engaged if the observer has to link two or more features to a location or object (see Figure 1XXX; Luck & Ford, 1998).

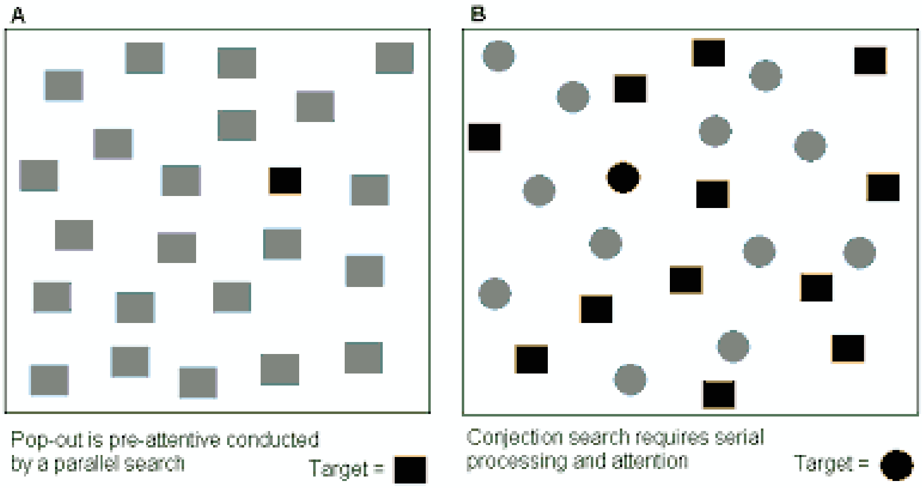

Figure 1.1. Treisman's Pop-out and Conjunctions Visual Search Stimuli

Treisman’s second search category describes a more effortful and systematic search that occurs when the target has a combination of two or more features, some of which may be shared with distractor objects (non-targets). When searching for an object that shares one or more features with those around it, attention is required to resolve ambiguities around discrimination of the object. Unlike the single feature search, conjunction search is slowed by increasing numbers of distractors and the observer must resort to a systematic process of directing attention to the job of detecting the target. In contrast, serial search produces a function with a positive correlation between the number of distractors and reaction time. Findings from Event Related Potentials (from electrophysiological studies) clearly show the engagement of attention when, in order to successfully identify a target, a person doing a conjunction search task needs to combine two features of a single object to find the target (Luck & Ford, 1998). The feature integration model also generated later modifications to explain some of its less consistent results, such as a shallow slope in a conjunction search task. As such, the guided search model developed by Wolfe et al. (1989) proposed that in some conjunction search tasks, the parallel processes involved in the early, preattentive stages of visual search, guide and inform serial search, thus increasing search speed and efficiency. For example, knowing a red square is the target, an observer can ignore all stimuli that is not red, thus being able to easily ignore all green or yellow objects in an array. This information, guided by the search requirements (red object, not green or yellow) narrows the search criterion and leads to a more efficient search. Notwithstanding, visual attention is not a unitary process but rather involves an orchestration of both serial and parallel mechanisms to navigate, engage with, and move through the environment.

Because the ability to select and act on visual information in the environment is so critical to guide adaptive behaviour, many specialised visual search tasks have been developed to investigate specific components of attention and, as such, have been shaped by different aspects of attention. Examples of commonly used tests include: visual search (detecting the presence of a target among distractors); selective attention (a process of attending to a goal-driven search result while ignoring irrelevant information or distractions); sustained attention (the ability to maintain the effort required to detect and report a pre-defined target over time); and divided attention (the ability to attend to two or more tasks at once). Some of the most prolific behavioural tests designed to access these attentional components, used in research and pathology assessments, include: simple reaction time tests (RT) where the participant has to respond correctly to the onset of a predictable stimulus with unpredictable timing; tests looking at divided attention where a participant is to attend and respond to two different targets at once; and the continuous performance test (CPT) where non-targets are presented in a monotonous stream along with the inclusion of infrequent and irregular targets that are to be correctly detected and reported. In summary, exploring the extent and limitations of visual attention has created a vast library of tasks designed to emulate the natural environment where hunting for a particular item on the supermarket shelf or being able to navigate through a busy intersection creates differences between people and situations.

Attentional Processes in Older Adults

Research has indicated that, compared with younger counterparts, older adults are less able to select relevant information from their environment. In particular, older participants are slower to shift attention to potential target stimuli, are significantly slower in allocating attention when orienting to a target and are less accurate at selective attention tasks (Lorenzo-López, Amenedo, & Cadaveira, 2008; Plude & Hoyer, 1985). For example, there is a steady, linear decline in processing speed from around 20 years of age which continues to the end of life (Salthouse, 2009) and performance on complex attentional tasks, such as divided and selective attention, also declines significantly with age (Agnew, Phillips, & Pilz, 2020; Lezak, Howieson, Bigler, & Tranel, 2012; Zanto & Gazzaley, 2019). Several explanations that purport to explain these changes suggest a few common, core deficits may be associated with these changes in later life. Hypotheses targeting sensory deficits, changes in attentional inhibitory processes, and decline in speed of processing have each provided plausible explanations for the reported decline in age-related attentional processes.

Sensory Deficit Hypothesis

Sensory deficits are purported to play an important role in cognitive changes associated with ageing. For example, significant correlations exist between older participants' performance in cognitive activities and their visual and/or auditory abilities (Kensinger, 2010; Nagarajan et al., 2022; Phillips et al., 2022). Notably, by their early eighties, many adults have experienced a significant loss of hearing and a markedly reduced ability to discriminate colours and luminance, and a reduction in cognitive flexibility and inhibition (Kensinger, 2010; Shende, Nguyen, Lydon, Husain, & Mudar, 2021), thus leading to a significant loss of accessible sensory information. For example, gradual onset hearing loss, cataracts, macular degeneration, and glaucoma are specific examples of sensory deficiencies that lead to a loss of stimulation to sensory processing areas, and are hypothesised to result in increased risk of cognitive impairment and decline (Cao et al., 2022; Hwang et al., 2022; Lindenberger & Baltes, 1994; Nagarajan et al., 2022; Whitson et al., 2018). In fact, a meta-analysis examining both longitudinal and cross-sectional papers identified that those with visual impairment in older age were at a significantly higher risk of cognitive impairment and dementia (Cao et al., 2022). Sensory deprivation hypothesis proposes that the mechanism behind these findings is that long periods of sensory deprivation result in neuronal atrophy and thus cognitive deterioration (Valentijn et al., 2005), and may even result in loss of mobility and the ability to care for oneself (Armstrong et al., 2022). In many cases, early treatment of sensory loss has led to improvements in sensory processing and resulting cognitive functioning (Denham & Golub, 2022). For example, the IMPACT study (Smith et al., 2009) targeted central sensory processing systems of participants identified as having significant hearing loss. Eight weeks of home-based computer training delivering auditory stimuli resulted in significant improvement in in both attention and memory functions for those in the experimental group. However, two studies had also found that cataract surgery, carried out with the aim of restoring sensory activity, failed to provide any significant improvement in cognitive ability (Kaarin J. Anstey et al., 2006; Hall, McGwin, & Owsley, 2005) instead suggesting that shared neural deficits associated with both cognitive and visual decline mean that although cataract surgery assists visual function, the cognitive deficit remains. Notwithstanding, there appears to be a clear connection between age-related visual impairment and cognitive decline (Cao et al., 2022) and visual functioning is clearly connected with attentional functioning in older people (Peng, Gao, & Mao, 2017).

Attentional Inhibitory Deficits

The efficiency of attentional inhibitory processes also declines with age leading to greater difficulty ignoring distractions during activities that require focused attention (Dempster, 1992). Because this change is not consistent across individuals or age groups (Harada, Natelson Love, & Triebel, 2013), the effect is greater variability in performance across trials for the individual, as well as greater variability across participants (Collette, Germain, & Hogge, 2009; Erel & Levy, 2016; Hasher, Lustig, & Zacks, 2012; Hasher, Stoltzfus, Zacks, & Rypma, 1991; Hasher & Zacks, 1988; Hasher, Zacks, & May, 1999; Kim, Hasher, & Zacks, 2007). This inhibitory decline is one of the notable accounts of cognitive change that affects attention and related performance for older adults. The significance of poorer ability to inhibit distractions is the inability to ignore irrelevant environmental information; potentially interfering with top-down attentional processes and thus crowding out task-relevant information. Additionally, in visual search tasks, older adults are more likely than younger participants to respond to previously relevant but now irrelevant task information thus interfering with new target search goals; a failure of *deletion* of information that was relevant, but is now irrelevant, or information that was never relevant (Campbell, Lustig, & Hasher, 2020). The cumulative result is slower visual search performance and increased target selection errors (Hasher, Quig, & May, 1997; Kensinger, 2010). Contrary to this simple description of attentional inhibitory deficits, McDowd (1997) provides evidence of a significant lack of consensus around the role of age-related deficiency in inhibition during attentional tasks. It is proposed that attentional inhibition may be made up of a number of independent functions rather than being a unitary construct, and age-related deficits may not affect all universally. For example, based on the outcome of negative priming studies, older adults were reported to perform equally with a younger sample in location priming, but not object priming suggesting a dissociation possibly in the *what* and *where* visual pathways, signifying that the identity pathway is affected in older adults, but the location pathway is not (McDowd, 1997).

Processing Speed

There have been a number of theories that propose that all cognitive changes could be explained by a single process, or a few processes (Dempster, 1992; T. A. Salthouse, 1996). Aside from Dempster (1992) and his inhibitory mechanism theory of ageing, a prominent account of cognitive decline, which relates particularly to attentional processing, is the processing speed hypothesis (Birren & Fisher, 1995; Birren, Woods, & Williams, 1980; Timothy A. Salthouse, 1996). This theory proposes that many cognitive performance deficits are related to taking longer to process cognitive information than younger adults – that is, slower processing speed. Measures of processing speed have included *decision speed* which is usually measured in terms of time to respond to a complex cognitive problem, or *psychomotor speed* which is measured via simple tasks such as finger tapping or marking figures on paper. The most recognisable measure of processing speed is *reaction time*, where a speeded answer is given in response to a visual or aural stimulus. For example, for a participant to provide a response in a speeded attention task, say visual search, a briefly presented stimulus must be detected by a sensory system, selected by the attention system, and then made available for the response. Because these stimuli tend to be available for only milliseconds, each system must complete processing while the stimuli is still available, and then move the outcome to the next processing stage. If, as suggested by Salthouse (1996), any of the stages are processed too slowly, the stage of processing remains incomplete and thus passes incomplete data to the next processing stage. The consequences of this slower speed include incomplete processing, errors in response, reduction in the availability of previously processed information, and erosion of important early processing stages (Clay et al., 2009; Adam Gazzaley et al., 2008). This inadequately-processed information then leads to poorer encoding, and incomplete storage of environmentally-relevant information. For example, a comparison between a younger and older group on the Wisconsin Card Sorting Test (WCST) suggested that, compared to younger participants, older adults were unable to make use of the covert feedback information. The authors maintained that this was due to the older people's slower processing speed, leading to an inability to fully process each component of the feedback due to the time-limited nature of the task (Fristoe, Salthouse, & Woodard, 1997). Notwithstanding, this explanation remains controversial due to the use of paper-based testing at that time that did not take into account hand-motor speed (Ebaid & Crewther, 2020) and the inability to directly test this hypothesis. Despite the questions around the mechanism behind the phenomenon, slowed cognitive processing speed remains an observed marker of cognitive ageing. For example, a major study examining decision making speed of a sample of 1.2 million participants (collected via online assessments) aged between 10 and 80 years indicated that reaction time (on correct trials) began to slow at around 20 years, continuing to around 60 years at which time there was a steeper decline in time to make a decision. In the older group, the decline was attributed to needing more information to make a decision, which was compounded by overall slowing mental processing and speed (von Krause, Radev, & Voss, 2022). Further, a study that compared age-based performance on tasks requiring manual dexterity (Coding & Symbol Search – WAIS-IV; pegboard task), statistically controlled for motor speed, found that results still correlated with age, indicating that older people's cognitive processing speed was slower than their younger cohort (Ebaid, Crewther, MacCalman, Brown, & Crewther, 2017).

Use It or Lose It?

Among other things, attention allows us to seek out landmarks and avoid obstacles as we navigate our environment. Attention is the element that drives us to observe, search, check, and recognise. In fact, without attention we cannot focus adequately to take in information from our environment. The everyday task of driving is a good example of a real-world attention situation where visual search is engaged as the driver scans for relevant and critical environmental information (e.g. brake lights, pedestrians) that may or may not appear in proximity. This scanning allows the driver to appropriately adjust his/her behaviour to accommodate environmental demands. However, once the route and the complexities of driving have been mastered and frequently repeated, the basic and well-practiced mechanics of the task change from conscious control (high attentional load) to requiring less attention investment for successful execution and, although there remains a need to adjust to environmental complexities, the frequency of these repeated learnings leads to an automatic, behavioural, rather than a heavily-cognitive, response over time (Lu et al., 2020; Shiffrin & Schneider, 1977). Automaticity occurs across many motor tasks and has even taken a place in our common vernacular – "just like riding a bike" implies that once a task is learned, the ability is retained thereafter. However, while the physical and motor requirements of driving are frequently retained well into later life, cognitive limitations caused by disease (e.g. mild cognitive impairment, dementia) are often the harbinger of driving cessation (S. A. Murphy et al., 2022; Scott, Liddle, Mitchell, Beattie, & Pachana, 2019).

However, notwithstanding the impact of disease - as discussed earlier - there remains substantial evidence to support the assertion that attentional functions decline in ageing. In particular, the ability to ignore irrelevant environmental information, and to react quickly and accurately to sudden events are common complaints from older members of the population. One possible explanation for the decline in visuo-spatial attention is the 'simple' medical explanation that physical changes result in deterioration of the mechanics of visuo-spatial attention (the impact of cataracts, macular degeneration, and so on). Interacting with this physical reality, however, is that changes in visuo-spatial attention can also be a consequence of changes in *behaviour*, such as less frequent engagement with activities that require attentional processes. For example, a frequent comment from older drivers is that after retirement, there is no longer a need to drive in traffic. Consequently, over time, the experience of driving in busy traffic situations becomes stressful and difficult, and the older driver tends to further avoid high-traffic times and situations, thus losing that crisp attentional confidence previously so easily accessible for such journeys.

Research has shown that retirement frequently leads to behavioural changes that result in cognitive decline (Atalay, Barrett, & Staneva, 2019; Calatayud, Lozano-Berges, Peralta-Marrupe, Latorre, & Gomez-Soria, 2022; Hamm, 2020), but see (Alvarez-Bueno et al., 2021 for a conflicting view). In order to examine this phenomenon in the context of age-related behaviour leading to attentional changes, the example of choosing not to drive during high traffic will be expanded. Over the years, when a person engaged with their fellow drivers on congested roadways on their journey to work, they would have built up the attentional and reactional skills to seamlessly meld into the traffic flow. Their unconscious ability to anticipate and react to known and unexpected events on the road could be described as being the *edge* they had achieved as a consequence of the cognitive demands of driving. Attentional aptitude would be well-honed, and the driver could probably listen to the radio or engage in a conversation during this trip without any noticeable deterioration in responding to the busy environment. Usually after retirement there is no requirement to join the morning and evening commute and so without the ongoing stimulation needed to maintain that edge, the attentional and reactive skill built up over time, declines. Anecdotally, a frequent reason for driving self-regulation is the difficulty of driving in the morning commute which often results in driving stress for the retired, older driver and the decision to make alternative plans (Vivoda et al., 2022). This assertion is supported by K. J. Anstey, Li, Hosking, and Eramudugolla (2017) who identified that fewer kilometres travelled predicts driving cessation in 70 plus year old adults, which happens after retirement. Additionally, despite preferring self-determined mobility, some older people also cite increased anxiety about driving particularly regarding the behaviour of other drivers (aggression, carelessness, rudeness) and health problems that make driving more challenging (such as poor night vision; Gardezi et al., 2006). These and other decisions lead to fewer situations where challenging driving situations are undertaken and, over time, the skill and confidence needed to confidently drive in these situations diminishes.

Although behavioural changes do impact attentional resources after retirement, an exception to the potential for detrimental loss of attentional assets may be that of expert drivers. An expert driver is categorised as one who has completed professional driver training and drives as part of their work role, as distinct from an experienced but non-expert driver (McKerral & Pammer, 2021). Examples of expert drivers include emergency services employees, taxi drivers, public transport drivers, and truck drivers. Importantly, although all categories of expert drivers complete mandatory driving training, emergency services employees undergo specific, detailed, and over-practiced training to ensure safety and skill in challenging contexts such as pursuit driving. The nature of this training involves purposeful, active visual search for potential unsuspecting hazards (e.g., pedestrians, other vehicles) while engaged in hazardous driving. This emphasis on broadening visual attention to capture high-threat hazards is a consequence of the propensity in non-expert drivers to narrow visual attention to a specific, important target (such as a pursued vehicle), or when confronted with challenging driving conditions (Crundall, Chapman, France, Underwood, & Phelps, 2005; McKerral & Pammer, 2021; Pammer, Raineri, Beanland, Bell, & Borzycki, 2018). The important point to be taken from this is that there is evidence that such training does in fact target, change, and improve attentional functions, and that due to the over-practiced nature of the training, these consequential cognitive changes are likely to persist over time (Krampe & Charness, 2018).

Following from such evidence, it is apparent that training on specific tasks to develop expertise has significant and long-standing benefits. In the pursuit driver example discussed above, this training has been a physical task (learning to drive in a specific way), but the training has also strongly targeted cognitive components of the driving task such as focused attention, vigilance, and the ability to discriminate between important and distracting environmental stimulation, all at speed and under pressure. Consequently, the question arises as to whether cognitive training could benefit other populations, specifically older adult drivers. In a recent review by Castellucci, Bravo, Arezes, and Lavallière (2020), the benefits of computer-based training programs targeting driving-related skills resulted in reducing the number of at-fault motor vehicle accidents, as well as enabling older drivers to continue driving for longer, although the only cognitive improvement reported was an increase in processing speed. Further, the review targeted improvements in safe driving via self-awareness, skills, knowledge, driving behaviour, and/or reduced involvement in motor vehicle accidents, however there was little emphasis on other activities, other than driving, that may preserve quality of life for older people. Therefore, cognitive training is an important area that may benefit older people particularly to preserve or even improve independence and cognitive functioning (Castellucci et al., 2020). The topic of cognitive training is explored fully in Chapter 2, which examines the history, methods, success (or otherwise), and benefits of cognitive training more closely.

Summary

This chapter has examined the importance of attention as a critical neural resource for maintaining activities important for independent living and later-life wellbeing. Early theories of attention exploring the process of gating, competition, and selection of relevant information into short-term memory has been discussed, but of particular interest are the limitations of attention and the use of these limitations to study attentional processes particularly visual search, reaction time and vigilance. Visual attention is a mechanism to manage relevant information in a crowded, distracting, and overwhelming visual environment, and the decline in these capabilities can lead to loss of independence for older adults. Sensory deficits, slowing neural processing speed, and age-related changes in the ability to ignore distractions have been identified as potential predecessors to cognitive decline, but losing the motivation and impetus to engage in challenging activities that stimulate attentional resources may also be a contributor to these age-related changes. Despite the origins and because attentional resources decline in older people, there may be a benefit in maintaining and/or restoring attention in later life. As such, cognitive training designed for and targeting cognitive functions is explored further in Chapter 2.

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Chapter 2: Cognitive Training and Transfer of Training Gains

In the previous chapter, attention was described and discussed as being an important cognitive operation that naturally declines with age-related physiological and social changes. These changes were explored in terms of four explanatory theories: the sensory deficits theory (Lindenberger & Baltes, 1994), where normal age-related decline in sensory processing leads to impoverished information being available for neural processing; the inhibitory deficit theory (Dempster, 1992) in which the ability to ignore irrelevant information causes processing errors and slows neural operations; the processing speed theory (T. A. Salthouse, 1996) which describes how, due to normal ageing, the speed information moves through processing stages slows, leading to incomplete and degraded information at each neural stage, thus resulting in poor cognitive functioning; and lastly, the propensity to reduce or cease some activities, often after retirement, is purported to lead to a loss of associated cognitive skills (Almond, 2014), particularly for activities that require fast, accurate attentional responses, such as driving. Although this has been nominated as *use it or lose it*, there remains some disagreement as to whether this is better described by cognitive reserve (Stern, 2009, 2021). The difference between the two is that cognitive reserve theory maintains that preservation of cognitive functionality in old age is as a consequence of early-life cognitive activity, particularly education, that then provides an enduring buffer against the effects of neural damage over time (Almond, 2014). On the other hand, *use it or lose it* proposes that cognitive preservation is reliant on a lifetime of brain challenging activity, particularly in later life (Almond, 2014). Notwithstanding, the approach taken in this thesis is the disuse-perspective or use-dependency theory described by

Salthouse (2006) which suggests that lack of ongoing use results in a degeneration of cognitive ability over time.

Age-related Brain Changes and Performance Variability

Neural indicators of age-related changes in brain structure include reduced volume, decreased white matter integrity, lessening of neural connectivity and cell function, and declining cerebral blood flow (Park & Reuter-Lorenz, 2009). Physical theories of ageing that account for these changes include loss of neural differentiation (due to neural compensation from other brain regions), variation in effective brain maintenance, and neural inefficiency, although these accounts have been challenged as being descriptive only and lacking in empirical rigor (McDonough, Nolin, & Visscher, 2022; although see later in this chapter for further discussion). Early stages of chronic disease such as Alzheimer's, and other dementing illnesses, are known to result in pathogenic changes to the brain (Tromp, Dufour, Lithfous, Pebayle, & Després, 2015), plus brain injury, including stroke and transient ischemic attack, create chronic impairment that have been associated with poorer cognitive performance in ageing (Biesbroek & Biessels, 2023).

Despite these adverse changes, the ageing brain can compensate to some extent, via neuroplasticity; a process of reorganising and reallocating function to other brain areas (Park & McDonough, 2013) although noting that these benefits are not consistent across individuals. More positively, neuroplasticity has been identified as a key element of brain change, including compensation after injury but also as a consequence of learning (e.g., when learning a second language or when learning a musical instrument; Wang, 2022). Of note is that when learning a second or subsequent language, regardless of the age of the learner, it appears that neuroplasticity is evident early in the learning process but there is a point of expertise at which neuroplasticity peaks and then declines, possibly due to specialisation (Gallo, Novitskiy, Myachykov, & Shtyrov, 2021). Increases in blood flow, white matter change, and increases in neural connectivity and efficiency have been identified as the underlying mechanisms of neuroplastic changes (Román et al., 2017).

There is also recent evidence of exceptional cognitive performance despite increasing age – referred to as super-agers (Klinedinst et al., 2023) – who appear to be able to avoid the build-up of tau plaques associated with normal ageing as well as amyloid tangles present in the brains of those with mild cognitive impairment (MCI; Hoenig, Willscheid, Bischof, Van Eimeren, & Drzezga, 2020). Despite the origins of these differences acquired over a lifetime, each add to the variability in results reported in studies of cognitive performance in older people (Laplume, Anderson, McKetton, Levine, & Troyer, 2022; Morse, 1993).

Regardless of the origins of age-related cognitive losses, the focus of regaining those losses has become a prominent area of research (e.g. Ballesteros, Kraft, Santana, & Tziraki, 2015; Bernini et al., 2023). Age-related brain changes that lead to decline also lead to cognitive impairment that can interfere with an individual’s ability to care for themselves, engage in preferred activities, and to live in their own home. Generally, older people expect to live independently throughout their lives but frequently loss of cognitive function leads to institutional or nursing home care (de Jong, Zeidler, & Damm, 2022). Those who live in permanent residential aged care experience, and are at higher risk of, mental health disorders such as anxiety and depression, often due to social isolation, loneliness, polypharmacy and poorly-targeted care (Amare et al., 2020; Pagone & Briggs, 2021).

Therefore, there is a lot of motivation to stay well and independent in old age (Hatcher, Chang, Schmied, & Garrido, 2019). Enabling older people to live independently in their homes is preferable in an economic sense as well as being in the interests of the individual (Hatcher et al., 2019; Stewart, Crockett, Gritton, Stubbs, & Pascoe, 2014). As an example, it costs the Australian taxpayer less to provide quality aged-care services in the individual's own home than it does to provide institutionalised care (2020-21: $7.7 billion on home care supports and $14.1 billion on residential care; http://health.gov.au). Therefore, providing appropriate age care to those over 65 years has become a policy, fiscal, and health issue due to our ageing society (Pagone & Briggs, 2021). Furthermore, those with cognitive impairment are more likely to be admitted to residential care (P. Chen et al., 2023; de Jong et al., 2022) and so those approaching their older years are interested and motivated to retain their cognitive health and independence and are seeking out opportunities to do so.

Historically, ageing came with an expectation of some degree of cognitive decline; in fact, for many older people, there is an expectation that ageing includes a gradual decline into Alzheimer's disease or another form of dementia or impairment (Fletcher, 2022). However, research has revealed that, not only is it a relatively small proportion of older people who are diagnosed with a dementing disease, but also that there can be a retardation of cognitive ageing, in a way that is more under individual control. For example, it is now better understood that lifestyle has a major impact on successful ageing; such things as social inclusion and social contact have been found to delay the onset of cognitive decline and to maintain cognitive health for older people (Bruggencate, Luijkx, & Sturm, 2018; Krivanek, Gale, McFeeley, Nicastri, & Daffner, 2021; Oh et al., 2019; Wan & Weissert, 1981). In fact, maintaining a healthy social network has been identified as an important brain-saving strategy strongly encouraged for those nearing or passing 65 years (Oh et al., 2019).

A significant component of social connectedness is transport – the ability to access the social groups and activities that maintain brain health and wellbeing. However, ageing often negatively affects driving capabilities to the extent that older adults either choose to stop driving due to lack of confidence and concern, or because they are assessed as being unsafe on the roads (Vivoda et al., 2022). For some, alternative forms of transport are not available, such as those who live in remote or isolated communities (Ko, Kalesnikava, Jurgens, & Mezuk, 2021). For many older people, losing that mobility is a significant health and wellbeing setback as driving represents autonomy and independence (Baudouin et al., 2023; Pellichero, Lafont, Paire-Ficout, Fabrigoule, & Chavoix, 2021). In fact, driving cessation in older people is related to depression and decline in cognitive function as well as reduction in social connection, which ironically leads to further decline (Chihuri et al., 2016). Therefore, driving capability is often held in high regard by older people and as such, there is high motivation to pursue methods to maintain the ability to do so.

The recognition that a lifestyle that is healthy for the heart is also healthy for the brain, with commensurate food and exercise providing an opportunity to delay or avoid age-related cognitive decline (Krivanek et al., 2021). Cognitive training for older adults is another area that has emerged as a strategy to limit the impact of ageing on brain health. Consequently, there has been an upsurge in the number of studies exploring the effects and benefits of cognitive training for older adults, however the outcome for such interventions has been variable (Nguyen, Murphy, & Andrews, 2022; Traut, Guild, & Munakata, 2021; Yun & Ryu, 2022). In particular,

Brain Plasticity, Cognitive Training, and Transfer of Training Gains

The ability to develop new responses to the environment and change behaviour is fundamental to survival of all animals. Learning, in this context, refers to the slow, practice-dependent learning often used in complex skill acquisition or rehabilitation of lost skills, as distinct from the effects related to adaptation or the fast learning that comes from simple familiarisation (Green & Bavelier, 2008). Salthouse and Somberg (1982) suggest that learning that results in increased expertise or efficiency is a qualitative transformation that comes from familiarisation but is developed over repeated exposure to components of the task. The authors use the example of learning Morse code, where expertise develops because of two mechanisms: *errorless learning* of easy letter sequences, followed by *reduced error rates* after specific practice for more common errors. The outcome of these mechanisms is automaticity where, over time, there is less thought and conscious self-tracking (attention), eventually leading to expertise without conscious input at all. The main difference in attention investment between the two components is that when learning, attention is applied serially in a slower, effortful way, whereas when automaticity is achieved, attention becomes more efficient, with little effort and takes on mainly parallel processing (Shiffrin & Schneider, 1977). The neural explanation for this phenomenon is that when learning a new, complex skill, there is rapid growth in dendritic/axon synapses during initial learning. As the task becomes familiar and less prone to error, there is a pruning of those connections that have become irrelevant due to expertise, thus establishing a stable, efficient renormalisation similar to the pre-training levels (Lindenberger, Wenger, & Lövdén, 2017).

The emergent challenge from this examination of learning and automaticity is how to broaden the benefit of such efficiency to other tasks and potentially other cognitive functions. Training transfer is the generalisation, or transfer of effects from training, flowing from one learned task to another unpractised task. *Near-transfer* is when the skill or knowledge gain is able to be applied in a domain similar to that trained but slightly removed, or where there is overlap of processes for both the trained task and the outcome measure (Pahor, Seitz, & Jaeggi, 2022). In other words, transfer of training gains is the generalisation of training effects beyond the specific tasks or activities learned (Barnett & Ceci, 2002; Jaeggi, Buschkuehl, Shah, & Jonides, 2014). Again, performance gains that transfer to similar and related tasks are categorised as near-transfers, however, *far-transfer* describes training effects that go beyond the initial learning of a task but then generalise to skills and activities that have either less in common with the trained task, or transfer to a dissimilar modality, location or time (Barnett & Ceci, 2002). In the context of motor tasks, it is easy to think about transference to other similar or more distant tasks. For example, running training can improve performance in cycling, stair climbing, or swimming, and the mechanism that creates transference is increased leg strength and a more efficient cardiovascular system, so near-transfer as all activities use the same mechanism (Jaeggi, Buschkuehl, Jonides, & Shah, 2011). Interestingly, far-transfer, where training on a computer-based task results in improvement in a physical task is an interesting example that has demonstrated its effectiveness. For example, young tennis players who practiced speed, accuracy and tactics on a computer-based tennis simulator, increased performance, not only on the video simulator, but the improvement also transferred to on-court game performance (Raschke & Lames, 2019; Smeeton, Hodges, Williams, & Ward, 2005)[1]. Of note in this example is that the mode of training was different to the target task (far-transfer), and this also

[1] Refer to addendum at the end of this chapter for a detailed description of this study.

demonstrates that computer learning can transfer to well-learned, targeted motor-based tasks.

There is mixed evidence for transference in cognitive training and there are broad differences in experiment designs across the cognitive training literature which may account for some of the conflicting results. For example, in their review of memory training Rebok, Carlson, and Langbaum (2007) identified that training in multiple mnemonic strategies, or mnemonics combined with another cognitive activity, resulted in *subjective* improvements in everyday memory, but there was little evidence of transfer to other cognitive functioning. Given that their measure of subjective change lacked the rigor and objectivity required to accurately quantify improvements in memory, it is not surprising there was no evidence of training transfer in this study. Conversely, training in a simplified, customised version of the Useful Field of View (UFOV) test was associated with significant improvement in UFOV performance after ten training sessions (Edwards et al., 2002), demonstrating a good training outcome, but more importantly, six years later, those who improved their UFOV test performance were found to be involved in fewer at-fault motor vehicle accidents than those who did memory training or no training (Ball, Edwards, Ross, & McGwin, 2010). This result suggests sustained benefits over time, and thus transfer to other, more complex behaviours; an example of far-transfer in both mode (computer training to on-road changes) and time (benefits maintained over time).

There are a number of studies that report good evidence of far-transfer in an older adult population, including one that compared performance of 40 experiment participants (mean age 77 yrs) with 40 controls (mean age 78 yrs) on a number of near- and far-transfer tasks before and after targeted working memory and executive control training tasks (Zinke et al., 2014). The results identified near-transfer effects as well as nine-month maintenance of far-transfer effects. Of interest was that further analysis identified that both age and baseline performance moderated the extent of the transfer effects. Specifically, older participants achieved lesser transfer effects than their younger counterparts, but interestingly, those with poorer baseline performance made greater direct training gains and experienced greater transfer benefits. Another study by Roenker and colleagues (Roenker, Cissell, Ball, Wadley, & Edwards, 2003) looking at training transfer, administered either computer-based speed of processing training or specific driving skills training to a group of older adults. Speed of processing training comprised of around four and a half hours of individualised practice on modified UFOV tasks. The driving skill training comprised four hours of films viewed by participants on a simulator with a steering wheel and peddles where they practiced techniques for crash avoidance, managing intersections, and scanning. Interestingly, the authors found that the speed of processing training gains transferred to on-road driving, as indicated by fewer dangerous manoeuvres during an on-road driving evaluation. However, although the driving skills-trained group did improve on specific, procedure-related skills targeted in the simulator training, there were no significant changes to the incidents of dangerous manoeuvres during the on-road evaluation for this group. For the speed of processing group, on-road driving improvements were still evident at 18-month follow-up, but sustained improvements were not found for the driving skills group; the authors suggested that it may have been that the new procedures learned in the simulated exercises had been forgotten or replaced by more entrenched, old driving habits. This is an intriguing outcome given it would be expected that the simulator training would transfer more readily to a change in actual on-road performance rather than the speed of processing training. Even more interesting is the effects of speed of processing training being still evident after 18 months, far exceeding the benefits of the simulated driving training. The crux of this outcome is that firstly, it is a clear example of far-transfer to on-road driving skills from speed of processing training, but also far-transfer over time. The simulator training produced near-transfer to those skills trained in the simulator but failed to achieve far-transfer to more complex situations on-road or over time.

However, not all training programs report clear transfer effects. For example, one highly cited study attracted 11,430 viewers (of varying ages) of a BBC science programme entitled *Bang Goes the Theory* who participated in a six-week online brain-training study (Owen et al., 2010). Baseline measures of reasoning, verbal short-term memory, spatial working memory, and paired-associates learning were compared with retest results after six weeks of training. There were two intervention groups: one that trained on reasoning, planning and problem solving; the other intervention group trained on short-term memory, visuospatial processing, and mathematics. The control group practiced online information retrieval tasks. All groups improved performance on the trained tasks and returned improved performance on the benchmarked tasks, including those in the control group. However, the effect sizes on the benchmarked task improvements were small to very small with the control group improving to a similar extent as the experimental groups. The authors concluded the improvement in the benchmarking tasks represent nothing more than practice effects (Owen et al., 2010). However, keeping in mind that the purpose of the study was to debunk the utility of commercial, online brain training programs, there were a number of components of the study that may have contributed to the poor training transfer outcomes. For instance, there was no publication of the inclusion criteria for participants beyond stating that there were

52,617 who registered and of those, 11,420 completed the two benchmarking assessments and at least two training sessions. As well as no exclusion criteria, there appeared to be no dropout analysis, but rather the approach was to analyse the available data post-hoc. The age range was also very broad (ages 18 to 60 years) and there was no differentiation of performance across age groups. Each of these elements could be the source of confounds distorting any true results. Notwithstanding, this study remains one of a number that criticise commercial “brain training” programs and debunk the promise of cognitive gains that transfer to a wide range of everyday activities; their criticisms specifically targeting the lack of empirical evidence to support the claims of any far-transfer (see also Simons et al., 2016 for an additional review that supports the BBC findings).

Contrary to the BBC paper, a cognitive-training study targeting school-aged children provided evidence of significant transfer from improvement in working memory training tasks to improved performance on tests of fluid intelligence (Jaeggi et al., 2011). Presenting tasks in video-game format ensured training and control tasks were engaging but challenging. Interestingly, it was found that individual differences regarding the perceived difficulty of the practice task impacted training gains; where the participant perceived the task as challenging but not overwhelming, the training gains were greater, and transfer of the trained skills was maximised. However, if the participant found the training tasks too difficult there was little improvement in the task itself and no transference to targeted tests. There was also a significant positive relationship between the amount of improvement in the trained task and the degree of transference to the fluid intelligence measure (Jaeggi et al., 2011). It may be argued that such training gains and training gain transfer are more likely in a younger population where neuroplasticity is the norm rather than the lesser expectation of an older group. However, cognitive training gains have been reported but the training and transfer outcomes have been more variable in studies with older populations.

Cognitive Training and Older Adults

The goal of cognitive training in an older population is to rehabilitate, restore, or preserve cognitive function lost to the normal ravages of healthy ageing, rather than to learn new skills or enhance existing knowledge. Ultimately, the goal of cognitive training for older participants is to maintain independent living for longer (Zelinski, 2009).

Training Methods

In her review of transfer effects across a number of cognitive functions in older adults, Zelinski (2009) describes two major approaches for cognitive training: *strategy training* including compensatory strategies; and *extended practice*. Extended practice uses repetition to train a targeted skill resulting in measurable practice times and thus greater experience with the new skill. Conversely, strategy training provides a tool to connect familiar information to new and/or abstract information. A criticism of strategy training is that although learned strategies are seen to be helpful, after training they may or may not be implemented by the participant for a new targeted activity (Zelinski, 2009).

Strategy Training

Strategy training provides tools and supports to assist with specific activities, such as memory, problem solving, reasoning, and planning; for example, the use of mnemonics for memorising important information or the use of diaries to support prospective memory. Mnemonics training teaches associations between items, such as making a rhyme with the letters of a list to be remembered, and thus making the complete list easier to remember, but these techniques are seldom engaged beyond the task for which the skill was learned, so this method would not necessarily be utilised for something different, such as problems solving. Zelinski (2009) proposed that the failure of transfer of beneficial effects may be due to compliance issues or the ability of older adults to apply the techniques more widely and beyond the task being trained. This may also explain why those with poorer overall health, less education, and lower motivation gain little from strategy training (Zelinski, 2009). Furthermore, the way strategy training is taught appears to determine its effectiveness; for example, Denney, Jones, and Krigel (1979) improved performance on the game *Twenty Questions* but only after demonstrating how to use constraint seeking questioning skills rather than simply teaching the skill without demonstration.

The other component of strategy training is the use of compensatory strategies. These are learned methods to make a large task more manageable; for example, breaking problems or jobs into smaller chunks or steps, writing components down and mark them off as they are addressed, creating routines to manage day-to-day tasks, and using memory aids. These compensatory strategies act as a support to the target task via providing a method that leads to success and proficiency in the main task, rather than developing adaptive plasticity that comes about from practice on the targeted task itself (Cramer et al., 2011). Although successfully producing large and long-lasting effects for the trained tasks, strategy training, with or without compensatory strategies, has been less effective in producing any measurable transfer effects (Lustig, Shah, Seidler, & Reuter-Lorenz, 2009).

Extended Practice With or Without Adaptive Modifications

Another training method nominated by Zelinski (2009) is extended practice, or extended practice with adaptive training. In both cases, high repetitions of a task creates learning which, over a relatively short time, increases proficiency in the task and lowers the sensitivity threshold related to the task (Tagliabue, Assecondi, Cristoforetti, & Mazza, 2020). Ultimately this also creates a sense of confidence and willingness to continue. Adaptive training may be more effective in acquiring and maintaining the learned skill due to the process being less effortful than starting with a training task with complex components. Adaptive training uses errorless learning along with repetition, plus incremental increases in task difficulty as skill increases, to ensure there is challenge but not a sense of failure (Tailby & Haslam, 2003). Consequently, this method requires less self-regulation for the participant. Often the task to be learned is broken down into simple components resulting in the initial task being much easier than the final, target task. As learning and confidence increase, individual components are added back, taking the task difficulty to the next level, but never exceeding the capability of the participant. This process is repeated until mastery is achieved (Wolinsky, Vander Weg, Howren, Jones, & Dotson, 2013).

Salthouse and Somberg (1982) argue that there are three possible mechanisms that lead to repetition-related improvement at a specific task. Firstly, the type of information being extracted and processed from the stimuli may change due to repetition; for example, features of a target with shared characteristics to non-targets may become more salient as the viewer gains experience and thus are processed as a priority, resulting in a "qualitative shift in the type of information being processed" (Salthouse & Somberg, 1982; p179). Secondly, simple repetition can also result in a change in processing happening during the task; for example, after extensive practice, visual search can improve to the extent that ten targets can be detected as quickly as a single target (Neisser, 1967). The mechanism driving this improvement relates to repetition causing the search process switching from serial (as it was when the task was novel and during early practice) to parallel, resulting in significantly faster target detection (Salthouse & Somberg, 1982). Lastly, the attentional demands of a task may decrease or change due to repetition. This can occur as the components of the task becoming automatic, thus freeing up of attentional resources. This, in turn may allow more attentional resources to be directed to the more difficult components of the task or simply speed up the process resulting in faster responses. It is unlikely these three mechanisms work independently. It is more likely that change in one mechanism will flow on to another (Salthouse & Somberg, 1982). For example, learning and repetition of selecting the correct response key (left hand for yes, right hand for no) may go from slow, effortful responses where the participant takes time and makes errors in key selection at the beginning, but with practice the key selection becomes automatic resulting in faster responses, fewer errors, and more attentional resources being directed to the primary task.

A seminal work in the cognitive training for older adults literature is the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study, which was a large-scale, randomised, control trial that compared different training methods and included repetition. In the ACTIVE study, over 2,500 participants, between the ages of 65 and 94 years, were randomised to one of four conditions: a memory group learning a number of strategies; a reasoning group who learned abstract and everyday problem solving strategies; a speed of processing training group using adaptive and repetitive training techniques; and lastly, a no-contact control group (Ball et al., 2002). Findings indicated that participants who trained in each of the three intervention groups (speed of processing, reasoning, and memory), each made significant improvements on their respective trained tasks, compared to the control group on completion of the intervention. Four booster sessions, 11 months after the intervention, further sustained training gains with effects significantly maintained at two years follow up. Notwithstanding, there was no evidence of transfer of the training benefit to activities of everyday living (ADLs) and independent activities of daily living (IADLs) measured at one and two years follow up. The authors suggested that the absence of training benefits to everyday functioning might have been due to participants remaining in good physical and cognitive health with no functional decline (measurable by IADL and ADL observations and questionnaires) at the time of the study or in the two years following intervention, thus having less room for improvement. This is highly likely as the recruited participants were selected and screened to ensure they were each living independently and had good cognitive function. The choice of ADLs as a transfer measure also likely lacked sensitivity as ADLs are a measure of fundamental skills of living independently and any deficits generally indicate a need for ongoing home-based or institutional care. IADLs are more complex capabilities such as being able to manage finances and prepare meals and manage medications (Edemekong, Bomgaars, Sukumaran, & Schoo, 2022) but, if there is no deficit at commencement, they are unlikely to change within two years in the absence of a catastrophic event. The lack of sensitivity of ADLs and IADLs as a transfer measure is also supported by the high incidents of ceiling effects (43% functioning at ceiling on the daily functioning composite scores) at commencement of training. Of note however, was that the functional and cognitive decline rates measured across all participants at year one and two after the intervention were lower than that of the general population, suggesting this sample may have had an ongoing, cognitive advantage compared to those in the general population (Ball et al., 2002) or that the training had enabled them to continue to function independently for longer. The authors commented that participants were living independently at the time of the intervention and remained so at two years follow up indicating they had maintained their competence with self and household-care tasks. Two further follow up reviews, one at five years (67% of the original sample), the other at 10 years (44%) were specifically looking at longer-term evidence of training benefits as well as comparing the groups in their ADLs and IADLs, noting that both these measures are composites for quality of life (Gobbens, 2018) as well as predictors for entry into institutional care (Edemekong et al., 2022). The objective was to determine if, despite changes in ADLs not being evident previously, there would now be evidence that the training did transfer to longer-term benefits in overall functioning – a far-transfer effect (time and function) to abilities that assist older people to remain living independently. Results at five years indicated that, despite evidence that these benefits were dissipating, all participants in the intervention groups retained a significant benefit in their specific area of training. Of interest was that, compared with the control group, participants in all of the intervention groups reported less difficulty with IADLs (Willis et al., 2006), however the difference from the control group was only significant for the reasoning training group. Longer-term follow up (10 years) indicated that gains made on each respective trained function remained evident only for reasoning and speed of processing training. Of importance however, was that among those in the follow-up, compared to the control participants, upwards of 60% of those in all intervention groups self-reported fewer difficulties with IADLs and of these, the majority considered themselves as well-off or better than when they had first participated in the study (Rebok et al., 2014).

To summarise, the ACTIVE study (Ball et al., 2002; Rebok et al., 2014; Willis et al., 2006) demonstrates the long-term benefits of adaptive repetition and strategy training in a large population of older adults. Participants in the memory group were trained in the use of mnemonic strategies across a range of different memory situations; the reasoning training group used pattern recognition to teach problem solving; and the speed-of-processing group received adaptive repetition training in a specific divided attention, visual search task. However, one training method not yet discussed is multimodal training, which blends training components to enhance engagement, persistence in training and, importantly, has been found to be more enjoyable for older participants (Rieker, Reales, Muiños, & Ballesteros, 2022)

Multimodal Training

Multimodal approaches of cognitive training, as the name suggests, involves using more than one training component. Multimodal training for older people may include relatively few combined components; for example, learning new skills (e.g. language training) or engaging in cognitively challenging activities (such as *Bridge*) but often with a social component. Conversely, there are others that include numerous components such as exercise, nutrition information, coordination exercises, cognitive exercises and mindfulness, which may also include a social component. A current example is a recent randomised controlled trial by Brasser et al. (2022)[2] that compared multimodal training (n = 41) with memory training alone and then to a waitlist control group. The multimodal training included physical and

[2] Refer to addendum at the end of this chapter for a detailed description of this study.

coordination exercises, along with cognitive (working memory, attention) and mindfulness training, creative activation, psychoeducation about brain health, and a social component. Outcome measures included cognitive memory, working memory, attention, and fluid intelligence. There was also an expectation that wellbeing, stress, subjective memory performance, and brain knowledge would be improved for those in the intervention groups. Results indicated that the outcome for the cognitive training group and that of the *multimodal training* group was limited to a significant improvement in working memory, but only for the multimodal group despite the cognitive training group engaging mainly in memory training. Further, the multimodal group self-reported higher improvements in perceived improvements (everyday memory and stress) than that reported by the cognitive training group or the control group. Lastly, the authors maintained that their multimodal participants were more compliant and committed to their training tasks as indicated by targeted feedback. The results from this study support the idea that in multimodal training activities, there is usually considerable improvement in the task and a willingness to continue with the training as it is enjoyable. However, the complexity of the combined activities mean it is difficult to identify transference to other cognitive function, or any ongoing benefit (Lustig et al., 2009).

Computer-based games fall into the category of multimodal training, as there are so many active components (Kühn, Gallinat & Masacherek, 2019) but this tool for cognitive rehabilitation or preservation has a problematic history and likely a complicated future. Video games come in all shapes and sizes and, while the origin and initial goal of these games was entertainment, historically, research into gaming has investigated the harm caused by habitual use, such as addiction, social isolation, and violence (C. A. Anderson et al., 2010). However, since then, the evidence base for such criticism has been questioned (Ferguson, 2013). In 2013, Bavelier and Davidson (2013) put out a call to researchers, game developers, and neuroscientists to work together to identify and capture the cognitive benefits that flow from video gaming. The argument was that there is potential, particularly for action video games, to be used to train specific behaviours and brain function in a range of populations, including older adults, with the aim of rehabilitation and/or enhancement. Since then, there has been a lot of attention paid to video games in the cognitive training literature. However, despite many studies, meta-analyses and reviews, there remains an inability to clearly identify consistent methods, benefits, or the mechanisms that lead to restorative neural changes and plasticity (Kühn, Gallinat, & Mascherek, 2019). Moreover, as well as being difficult to identify which components of the games are effective, results are variable and difficult to interpret. For example, a recent study used a purpose-built, virtual environment to design a video game to train spatial navigation in older adults - *CityQuest* (Merriman et al., 2022). The objective of the game (and the study) was to train spatial navigation, obstacle avoidance, and balance control in a group of older adults. The authors expected that training gains for the target group (CityQuest group) would transfer to higher-order executive functions including working memory and attention via the high-level multi-tasking required to successfully play the game. Comparison groups each played a specific cut-down version of the game, those being a spatial navigation only group and an obstacle avoidance only group. In summary, the CityQuest group played the full game that included spatial navigation, object avoidance, and a physical balance component. Neither the spatial navigation or the obstacle avoidance group had the balance component, so each played the game, but their goals were to find their way around or to name and locate objects on the route and not pay attention to the other components of the game. The results were unexpected in that there was no significant improvement in direction judgement or landmark naming for any of the groups despite the CityQuest and spatial navigation group having specific exposure to these skills in their respective conditions. This result was attributed to probable ceiling effects as the average pre-training performance was already at 66% correct for all groups. However, the CityQuest group did show significant improvement in object location over that of the spatial navigation and object avoidance groups. Further, while the object avoidance group significantly improved on object recognition post-training, there was no such improvement for the CityQuest group, despite an equal element of object avoidance being in their version of the game. Speculative explanation by the authors suggested that the specificity of object recall was the main aim of the object avoidance only group, whereas objects were a secondary component of those playing the full game. Overall, one of the hypotheses was that the game training for those in the CityQuest group would transfer to executive function. To this end, the hypothesis was supported in that the CityQuest group significantly improved on the Trail-Making-Task (A and B) from pre- to post-intervention (Merriman et al., 2022). As an example, it is apparent in this study, despite achieving some of the hypothesised goals which is an encouraging outcome, these results are ambiguous and difficult to decipher. Therefore, although it remains difficult to identify the cognitive domains best to target, and how to accurately measure and interpret any gains, video games are an exciting avenue that promises to be beneficial for an older population. However, for an older population, using training tools that explicitly target the cognitive functions of interest appears to be a more practical approach to exploring the components of cognitive training and the transfer of training gains to activities of daily living and the preservation of independence.

Brain Changes Due to Cognitive Training in Older Adults

The brain is constantly receiving information. To make sense of and use this raw information the brain must firstly integrate from all the diverse sources and then send off specific information to the relevant, specialised, neural circuits (Lord, Stevner, Deco, & Kringelbach, 2017). Age-related neurodegeneration reduces the efficiency and speed of these information flows and processes, and normal compensatory support from other brain regions tends to add to the dispersion and decreased specialisation of cognitive function in an ageing brain (Chan, Park, Savalia, Petersen, & Wig, 2014). One recent brain imaging study looked at age-related changes in neural specialisation and identified that the mechanism of transfer after cognitive training is via increasing the level of neural segregation and neural efficiency: In a structural MRI study, Q. Chen et al. (2021) recruited a group of 84 adults aged between 60 and 90 years, all with amnesiac mild cognitive impairment. The participants were randomised to an intervention or an active control group and both completed four one-hour computer-based sessions per week over six weeks. The intervention group worked on a collection of speeded visual search tasks that were part of a commercial brain training package, and the active control group completed computer-based versions of crossword, sudoku and solitaire games. The outcome measure for near-transfer of training gains was the average score on the three subtests of the UFOV test, with the active control group showing little post-intervention change in the composite UFOV score, however there was significant improvement in the UFOV score for the intervention group. Far-transfer of training gains was confirmed based on pre-post results on a computer-based test of executive function (cognitive control and working memory). Of interest was that not all those in the intervention group demonstrated far-transfer and so each participant from the intervention group was further categorised into either learners or non-learners, based on their measure of far-transfer (performance on the executive function tasks). To determine training related brain changes, all participants completed pre- and post-intervention structural MRI. The overall objective of the study was to examine any changes in neural segregation and connection across the brain for all participants, but particularly for those who demonstrated training transfer. After comparing learners and non-learners' MRI data (pre- and post-), the results identified several divergent brain regions with measures of significant enhanced network segregation after training induced far-transfer (cingulate cortex, parietal regions, striatum, and thalamus). These results not only identified clear brain changes brought about by far-transfer of cognitive training gains, but also identified the importance of assessing global as well as network brain enhancement after training.

Time-locked event related potential (ERP) recordings have also uncovered neural changes that occur with near- and far-transfer after cognitive training. In a sample of 28 older adults (mean age 72 years; 14 intervention and 14 no-activity control), Mishra, Rolle, and Gazzaley (2015) analysed pre- and post-amplitude measures of visual ERP components, N1 and N2, after ten hours of training on an adaptive, speeded motion discrimination task (contracting vs expanding Gabor patches). An untrained visual working memory task (delayed recognition with interference) was also assessed pre- and post-training for both groups. The N1 and N2 ERP activity relate to cognitive processes; in particular N1 measures early attention allocation and N2 measures response inhibition (Ernst et al., 2013).

Behavioural results indicated significantly faster accuracy and reaction time in the trained motion discrimination task compared with controls, as well as a significant improvement in the unpractised fixed-speed motion discrimination task (near-transfer) but only for the intervention group. The intervention group also performed significantly better than controls on the untrained delayed recognition working memory task, which confirmed far-transfer effects. The authors stated that the results indicated successful training and transference of perceptual leaning to an untrained, but similar visual discrimination task, but also to a distant working memory task. The mechanism of transfer, supported by the ERP results, was proposed as being due to the greater allocation of attention in the more challenging motion discrimination trials driven by the rapid, but sequential presentation of the stimuli. It was suggested that this method of presentation made the patches appear to be overlapping, and thus more difficult to discriminate unless attention was focused closely on the stimuli. The enhanced (stronger and faster) N1 and N2 effects at Time 2 compared with Time 1 reflect the success of that challenge. Secondly, far-transfer to the working memory task after training was proposed as being due to an improvement in general cognitive control due to the challenging training task.

In their review of far training after cognitive training, Greenwood and Parasuraman (2016) proposed that cognitive training actually improved control of attention and increased the ability to suppress distractions, both of which come under the umbrella of attention. The engagement of the dorsal attention network (DAN) facilitates top-down selection of stimuli as well as consequential responses, plus the act of holding a target in working memory also engages distractor suppression. Early fMRI evidence has indicated increased activity in the DAN early in training but over time, that activity again decreased. The explanation was that this change is due to cortical tuning, which would suggest automaticity, as has been described earlier in this chapter (refer: Salthouse & Somberg, 1982). The process and benefit of automaticity is that the centralised, attentional control processes would be strongly engaged when a cognitive training task was novel and still quite challenging, and those processes would become faster and stronger as the training progressed. As expertise increased, that dependence on focused attention would lessen, freeing up those attentional resources for other components such as distraction suppression, which again, would be enhanced with continued training. Ultimately, the neural tuning is retained, and the effects outlast the training, allowing for far-transfer (Salthouse & Somberg, 1982). However, despite there being evidence of transfer effects detectable over weeks and months after training, there remain very few examples of longer-term benefits of cognitive training (Greenwood & Parasuraman, 2016).

Attention Training

As discussed in the previous chapter, attention is a cognitive gatekeeper that enhances the selection and focus on relevant environmental and internal information. Because attention is at the forefront of all information processing, without it we cannot monitor, respond, learn, or remember. Attention, including the ability to ignore distraction and control pre-potent responses, is essential for instrumental activities of daily living, such as driving. Moreover, it is likely that any impairment in attention is going to have a wide-ranging and negative impact on other cognitive functioning. Again, it has been previously discussed that normal ageing often results in decline of attention functions, however there is evidence of older adults demonstrating significant improvement and thus neuroplasticity for attentional tasks after targeted training. In their investigation of variable priority, dual-task and single-task attention training in a group of younger and older adults, Bier, Ouellet, and Belleville (2018) identified firstly, that all participants (younger and older) improved performance on the practiced single-task condition. However, older adults benefited from dual-task training to a greater degree than the younger adult participants, confirming that older brains do indeed benefit from cognitive training, and possibly that there may have been more room for improvement for the older group due to normal age-related cognitive decline (Karbach, Konen, & Spengler, 2017). Of particular interest was that another of the main aims of the Bier et al. (2018) study was to explore the possibility of training transfer to real-life activities, and for this the authors used an immersive virtual reality *passenger in a car* scenario with a challenging dual detection and memory task. In the older group, those in the variable training condition performed better in the virtual reality task than those who were in the single-task condition confirming transfer of training gains but noting that the dual-task trained participants were able to transfer their learned skills to a contextually different situation.

Aims of this Thesis

As discussed in these introductory chapters, attention is crucial to everyday life. Attention allows us to find a face in the crowd, to listen intently to a child's story, to speak to a passenger when driving, and to learn. Because attention deficits become more prominent in older age as part of normal, healthy ageing, the idea of reinvigorating attentional function is persuasive. This research aimed to examine the importance of attention as a key component of cognitive training and to demonstrate its contribution to the transfer of training gains. This examination was via the design and delivery of daily attention-specific training to a group of older adults. It was expected that the resultant training gains would transfer to measurable improvements in the three individual tasks of the UFOV® Test - an assessment of driving risk for older adults.

Although complementary, the cognitive roles of attention and working memory are different. Specifically, working memory maintains the attentional set during visual search, while attention is the tool for selecting and prioritising relevant stimuli (Oberauer, 2019). Therefore, it was expected that performance on the individual UFOV tasks would not benefit from working memory training, but instead UFOV performance would remain relatively stable between pre- and post-assessments. Of note is the method of training delivery which was an important component of the training strategy. It was proposed that enabling participants to complete their training in their own homes, on their own computer, and at their preferred time of day, would encourage acceptability, enjoyment and compliance.

Lastly, because of the many accounts of significant variance in benefits to older people who participate in cognitive training, personal attributes and individual differences were explored across the two training groups adults.

Thesis Structure

There are seven chapters in this thesis. Chapters 1 and 2 provide an introduction and review of the literature as it relates to attention and cognitive training. Chapter 1 reviewed attention as a central cognitive function and examines age-related changes in attention, and the major theories that explore those changes. This chapter, Chapter 2, has looked at changes in the brain due to ageing, and the importance of neuroplasticity, as well as discussing strategies designed to compensate for negative age-related effects. Cognitive training as a strategy is gaining momentum and so is examined in detail in this chapter.

Chapter 3 provides the full methods for the two chapters looking at transfer of training gains to the UFOV Test, including participant details and initial data comparisons. This is to prevent repetition, but this chapter also provides a full description of the analysis used for the UFOV chapters. Lastly, because of ceiling effects, the analysis of the first UFOV task, Processing Speed, is reported in Chapter 3.

Chapters 4 and 5 report the specific detail and outcomes for UFOV tasks Divided Attention and Selective Attention respectively.

Chapter 6 examines individual differences that contribute to the explanation of the training outcomes reported in Chapters 4 and 5.

Chapter 7 provides a summary of the findings of this thesis and how they contribute to the theory of attention in ageing, cognitive training, and transfer of training gains. Implications of the findings, not already considered in earlier chapters, are appraised along with considerations for future research as a consequence of these findings.

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Footnote 1 (p45): Raschke & Lames. 2019

The following summary provides additional detail about on-court tennis tactic performance improvements after video simulator training, compared with training as usual as reported by Raschke and Lames (2019):

Twenty-four junior tournament grade tennis players, all members of the Bavarian Tennis Federation, aged 10-14 years were recruited for the study. The experimental group (*n* = 12) were all from one from the same tennis academy, and the matched control group (*n* = 12) were selected from various clubs. This selection was to enable the variables of each of the experimental group to be matched with age, sex, playing level, years of practice, years of tournament experience and training volume.

Over the 12 weeks of the study, the experimental group replaced two of the usual training sessions with video-based tactical training sessions, while the control group continued with the standard training regimen. The video sessions consisted of video-feedback of the players' own games with the purpose of analysing their own on-court decisions, with discussion and guidance from their usual trainer/supervisor. The purpose was to incorporate tactic training with the traditional technical training common in tennis.

Tactical analytical competence of each player is measured pre and post intervention, by evaluation of each player's performance on the Video Tactic Test (VTT). This test is a recorded interviews of the participant evaluating scenes of selected plays. Each of these plays includes the identified constructs including service and returns, building the game, point preparation and finish, and on-court conduct. An overall score (average of other scores) provides an overarching comparison. The VTT on-video performance of each player is transcribed and evaluated by four expert examiners, blinded to the condition, the time of the test (pre/post intervention) and the player

Results indicated four of the six tactic targets with *on-court conduct* and *opening-return* not being significant, however all targeted tactic constructs showed improvement compared with the control group, after intervention. In particular, the score for *overall*, the measure of cognitive improvement from the intervention in total, along with most other constructs, was significant. Of note is that the authors also describe an observed improvement in real match behaviour of those in the intervention condition.

Although power analysis identified that the small sample size was only able to detect a large effect size ($ή^2$ => 0.14, $\alpha = 0.05$, $1-\beta = 0.95$), the results indicate that there was sufficient improvement, compared to the control group, to achieve this effect.

However, a concern with the selection of the control group remains to be addressed. In particular, the experimental group were all in the same club and therefore were likely to know each other. Although those in the control group were part of the broader tennis organization, they were distributed across other clubs. There is no information about how many clubs and how many may have been training together. This detail may have introduced a number of confounding variables including the effect of different coaches between the two groups, different team dynamics, competition among training mates, and different locations, among others. Other designs that recruited the control group from the same club, and statistically managed some variables, or even running a within-player design where pre-intervention training results were compared with post-intervention tactic performance using a repeated measures analysis may have overcome this potential confound.

Footnote 2 (p56): Brasser, Fruhholz, Schneeberger,.. Studer-Luethi. 2022

The aim of this study was to look at online cognitive training for older adults, to compare a multimodal cognitive training intervention (MMI: *n* = 41) with a single component model (CT: *n* = 37) in a group of participants aged between 65 and 90 years. A waiting control group was also included (WCG: *n* =41). All participants completed either MMI, CT or WCG in the first round of five weeks, followed by another five weeks of MMI, thus all participants received the targeted intervention, plus the MMI group had two doses of the main intervention. Prior to commencement (T1), baseline performance was measured for verbal memory, working memory, attention, and fluid intelligence. The same assessments were repeated at the end of the first round of online training (T2) and again at the end of the study (another five weeks later; T3). The MMI interventions included physical health tasks such as exercise and nutrition; coordination; cognitive training; mindfulness; creativity and a community component, made up of telephone contact, and skill building in communication and humour.

Overall, the results indicate a significant improvement in working memory performance in the MMI group compared to the both the CT group and the waiting control group. However, although upward trending was identified for other tested variables, there were no other significant results.

It is notable that there was high variability in compliance with the intervention activities across conditions, particularly the CT group. The authors attributed this to the longer time investment (15–20-minute blocks for the CT group compared with multiple 2–5-minute sessions for the MMI group). Higher compliance in the MMI group may have contributed to the lack of significant findings for any of the trained tasks for the CT group. Additionally, the addition of the MMI intervention to each group between T2 and T3 is likely to have confounded any clear differences between groups after T2.

Chapter 3: General Methodology and Results for Useful Field of View – Processing Speed

This chapter provides a detailed description of the methods employed to generate and analyse data for the experimental chapters 4 through 6. Consequently, each of those chapters includes distinct methodological information relevant only to that chapter, and a reference directing the reader to this chapter. This strategy avoids duplication across chapters.

The overall aim of the study, as detailed in Chapters 4 to 6, was to examine and potentially improve attention functioning in older people, using basic and easily available attention tasks that, with repeated use, would enhance general attention functioning with the benefits transferring to other, unpractised tasks. The main hypothesis was that those who trained on targeted attention tasks would have a measurable improvement in other attention tasks. It was proposed that a popular, and well-established test of driving related attention (UFOV test) could capture any changes in attention capacity and so individual UFOV task results (processing speed, divided attention, and selective attention) were the dependent variables. The independent variables were the three types of on-line cognitive training, those being the group of attention tasks, the working memory tasks, and the no training control condition.

Data were gathered for each of these experimental chapters across two waves of participants. The first wave of participants was allocated to one of two intervention conditions, and each completed two sessions: a pre-intervention testing session (Time2) and a post-intervention testing session (Time3). This group is hereafter referred to as the NoControl group. The other group of participants, the

WithControl group, completed an additional testing session (Time1) two weeks prior to the pre-intervention session (Time2) and then did a 14-day, no-activity period which served as a control period in addition to doing the intervention, as per the NoControl group (refer to Figure 3.1 for a visual description of these groups). The data from these two groups were combined for further analysis. The decision to combine these two waves was to overcome the challenges associated with recruiting high numbers of participants from an older population and to streamline the data collection and time commitment for those who did volunteer.

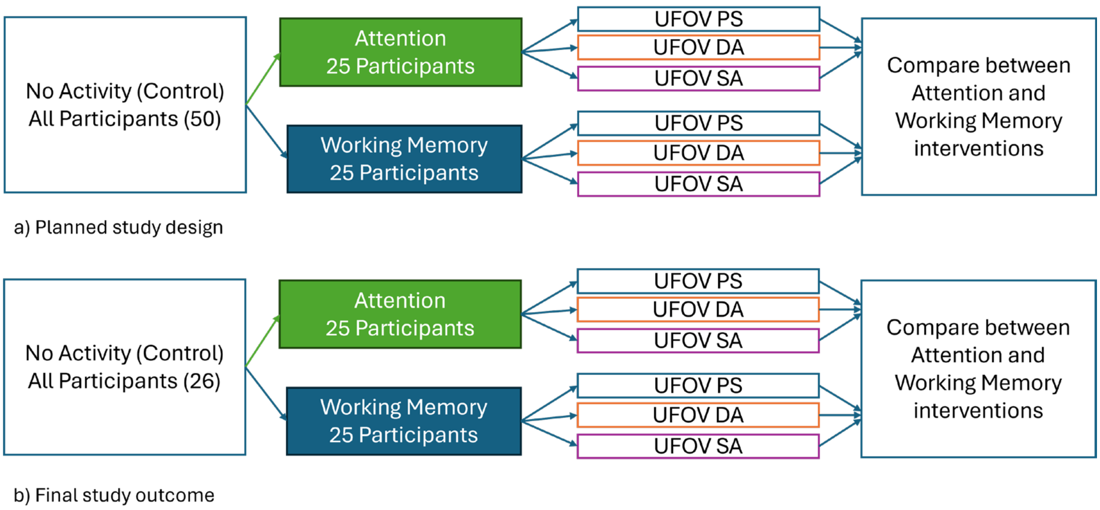

Figure 3.1. a) Graphic of planned study design with b) indicating that 26 participants completed the control period (Time 1 to Time2) rather than the planned 50. Twenty-four participants started the study at Time 2.

Participants

Fifty community-dwelling adults, aged 61 to 90 years (M = 73.6, SD = 7.4; 24 female and 26 male) with a current drivers' licence and regular driving habits, were recruited through posters, letterbox drops, and advertisements in local newsletters seeking participants aged 60 years and over. Applicants were screened by telephone; any who reported a history of stroke, brain injury, or with a diagnosis of dementia, were excluded. Applicants were required to have access to internet (they could access the intervention at the local library if they did not have home internet) and be able to complete the intervention daily. All participants reported normal or corrected-to-normal vision (checked within the last two years) and reported formal education ranging from nine to 21 years (*M* = 16.0, *SD* = 3.2). Summary demographic data for participants is presented in Table 3.1. Participants were fully briefed on the content and procedures for the study, both verbally and in writing (by email and again at their first laboratory session), prior to giving their written consent (all questionnaires relating to participant information and consent are included at Appendix I). The Australian National University Human Research Ethics Committee approved this study (HREC 2012-707). No remuneration was given for participation.

Table 3.1 Demographics and Driving History for All Participants.

	M	*SD*	Mdn	Mde	Range
Age (years)	73.58	7.36	73.15		60.83-90.48
Education (years)	15.98	3.18	16	16	9-21
MoCA	27.68	1.58	28	28	24-30
RSPM	49.50	7.70	50.50	49,50,52,55 [a]	32-60
Years driving	54	8.75	54	57	37-74
Accidents [b]	0.27	0.57	0	0	0-2
Klms/yr/thn	17,377	12,219	15,000	15,000	2,000-72,000
Klms/yr/now	12,396	9,116	10,000	10,000	1,000-55,000

Abbreviations: Moca = Montreal Cognitive Assessment; RSPM = Raven's Standard Progressive Matrices; Klms/yr/thn = Klms driven per year during peak driving time over life; Klms/yr/now = Klms driven per year now.
[a] Multiple modes
[b]Accidents (incidences that resulted in damage to the vehicle, including at-fault and no-fault) in the last 5 years
n = 50

Procedure

This section fully describes the procedure undertaken for the second wave of participants (WithControl). Those in the first wave (NoControl) completed all paper- and computer-based assessments and questionnaires prior to commencing the intervention described below (refer to Figure 3.2), otherwise their procedures and activities were the same.

Laboratory-Based Sessions

Participants attended three laboratory-based data-collection sessions each two weeks apart. In the first session demographic information and driving history was collected via questionnaire, preceded by a brief interview outlining experiment procedure and home computer requirements. Each participant then completed the Manchester Driver Behaviour Questionnaire (DBQ; Reason, Manstead, Stephen, Baxter, & Campbell, 1990), Perceptions of Driving Skills (White, Cunningham, & Titchener, 2011), and Self-rated Hazard Perception Questionnaire (Conlon & Herkes, 2008). Each of these questionnaires is at Appendix II. Following completion of the questionnaires, each participant was administered the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) to assess cognitive function. The computer-based tasks followed, which comprised a conjunction search task and the three Useful Field of View (UFOV) tasks that make up the UFOV® Test (see Measures section for a full description of these tasks). The computer-based tasks completed at Time1 became the baseline, for comparison with the commencement of the intervention (Time2) and after intervention (Time3). The computer tasks were counterbalanced across participants and the order was also varied across sessions for each participant. Lastly, participants completed the Raven's Standard Progressive

Matrices task (Raven, 2000) as a measure of general intelligence. The first session took around two and a half hours, including breaks.

The second laboratory-based data collection (Time2) happened after the 14-day period during which there was no experiment-related activity, as described previously, and so this 14-day period therefore served as a no-intervention control period. After this 14-day period (Time2), participants again completed the full UFOV Test and the conjunction search task and were then given verbal instruction for the home-based training activities. No other assessment or testing was carried out in the Time2 session. Instruction and practice were given for the home-based training tasks prior to each participant leaving the session, and assistance with setting up the training tasks on the participant's own computer at home was offered and arranged if requested. A written instruction book, relevant to his or her experimental condition (Attention condition [Att] or Working Memory [WM] condition; Appendices IIIa and IIIb) provided instruction on how to access and complete training tasks and was given to each participant prior to commencing the 14 days of home-based training sessions. A diary accompanied the instruction book, serving as a reminder and motivation to complete the daily training and provide opportunity for feedback on task difficulty, enjoyment, commitment, etc. (Appendix IIa and IIb). Participants were also able to contact the experimenter if they needed assistance during the training period. Time2 data collection and instruction to participants took around one hour. Four participants required assistance to set up the experiment on their computer in their homes. Of the four, two required more than one visit to address difficulties or problems accessing the online tasks. All difficulties and problems were resolved and there was no impact on participation or data collection.

The final session (Time3) was conducted after the 14-day period of home-based training. At Time3, participants repeated the UFOV Test and conjunction search tasks. Each participant then completed the DBQ, Perceptions of Driving Skills, and Self-rated Hazard Perception Questionnaire for a second time. On completion, participants handed in their training diary and were provided with feedback and a debrief about the study. With participant consent, comments were recorded. Where appropriate, these comments have been throughout the thesis to assist interpretation and to provide context for results. Time3 took around an hour to complete. Figure 3.2a and Figure 3.2b show a timeline of the control and experimental periods as they occurred for each participant. Table 3.2 provides a summary of laboratory-based task results across the three testing sessions.

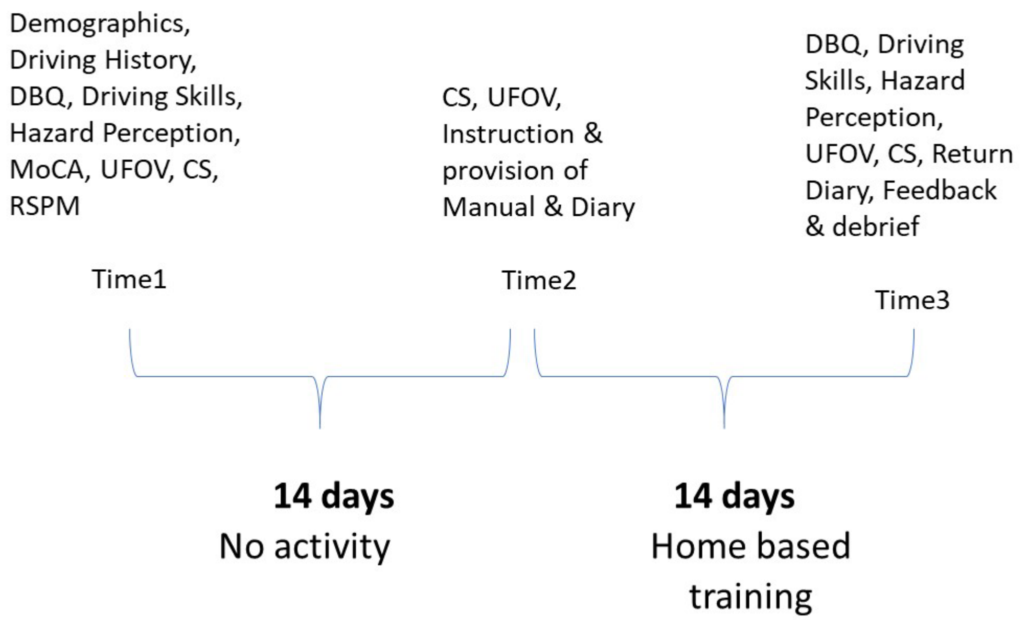

Figure 3.2a. Schematic of participation timeline and activities. DBQ = Manchester Driver Behaviour Questionnaire; MoCA = Montreal Cognitive Assessment; UFOV = Useful Field of View Test includes UFOV Processing Speed (UFOVPS), UFOV Divided Attention (UFOVDA) and UFOV Selective Attention (UFOVSA); CS = Conjunction Search; RSPM = Raven's Standard Progressive Matrices.

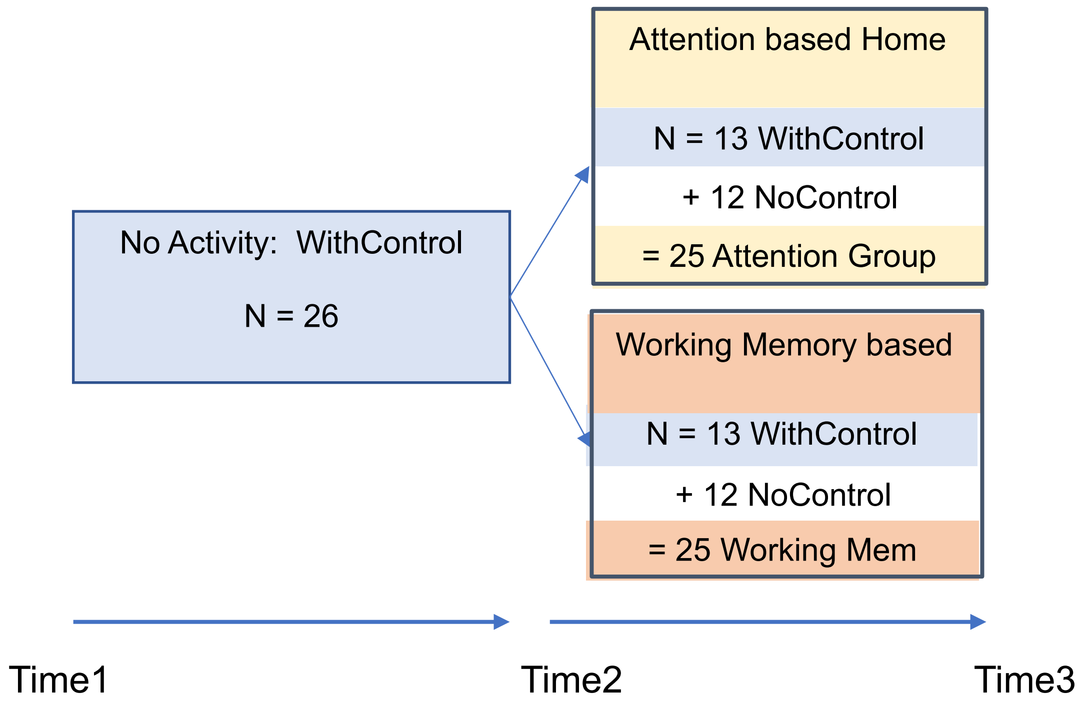

Figure 3.2b. Timeline of activities completed by participants in each experimental group. WithControl group completed all three laboratory-based sessions as well as the 14-day home-based training. NoControl group commenced their participation at Time2, completed the 14-day home-based training and Time3. A total of 50 participants completed the home-based training and included 26 participants who contributed to the control dataset. The conditions WM and Att were BS factors and refer to the type of training. All participants did the same cognitive and psychophysical tests at Time 1, 2 & 3 [WithControl group] or Time 2 & 3 [NoControl group]

Table 3.2. Descriptive Statistics for Study Variables at Time1, Time2 and Time3

	M	*SD*	*M*	*SD*	*M*	*SD*
	Time1		Time2		Time3	
CSRT (ms)	1605.69	379.83	1560.02	336.73	1355.20	332.02
CSAC (% correct)	94.81	2.87	94.44	3.66	93.82	3.70
DBQ Total	18.56	7.71	-	-	17.67	7.19
Driving Skills	12.42	4.44	-	-	12.35	4.24
Hazard Perception	27.44	5.49	-	-	28.02	5.30
UFOVPS (ms)	27.76	22.82	26.56	22.83	18.12	3.86
UFOVDA (ms)	89.43	97.37	78.16	87.58	37.55	46.12
UFOVSA (ms)	244.17	109.80	215.76	99.29	168.52	90.92

Abbreviations: CSRT = conjunction search – reaction time; CSAC = conjunction search accuracy; DBQ = Manchester Driver Behaviour Questionnaire; UFOVPS = Useful Field of View Processing Speed; UFOVDA = Useful Field of View Divided Attention; UFOVSA = Useful Field of View Selective Attention.
n = 50

Home-Based Training

All participants were assigned training tasks to complete at home on their own computer. These tasks were to be completed daily for 14 consecutive days between Time2 and Time3. All participants had access to their own computer or laptop and internet access at home to complete the training tasks. They each accessed a purpose-built webpage that linked to either the Att or WM home-based training programs. As part of the Inquisit licencing package (used to write all computer-based tasks except the UFOV Test), Millisecond Software© provided web-based data collection including participant access information and complete data storage for all home-based training sessions. All sessions were date and time-stamped which provided confirmation of each training sessions undertaken by each participant.

Participants were allocated to either the Attention (Att) or Working Memory (WM) condition each of which had a set of three training tasks for completion each day. Allocation of participants to each training group was according to a predetermined alternating sequence with the first participant to the Att condition, the second to the WM condition, the third to the Att condition, and so forth. Demographic, cognitive, and intelligence information were compared across groups (refer to Table 3.3), noting that there was a significant difference in MoCA test scores between groups. This difference is discussed in Chapter 4: UFOV Divided Attention, and Chapter 5: UFOV Selective Attention. Otherwise, there was no significant difference between group scores.

Table 3.3. Summary of Participants' Demographic Information Across Training Conditions

	Total Participants (n = 50) n (%) or mean(SD)	Att Training (n = 25) n (%) or mean(SD)	WM Training (n = 25) n (%) or mean(SD)		
Age	73.6 (7.3)	74.0 (7.1)	73.2 (7.7)	$t(48) = 0.39$	$p = .70$[a]
Sex					
Male	26 (52)	14 (54)	12 (46)		
Female	24 (48)	11 (46)	13 (54)	$\chi^2(2, N = 50)$	$p = .78$[b]
Education	16.0 (3.2)	15.8 (3.1)	16.1 (3.3)	$t(48) = -0.31$	$p = .76$[a]
MoCA	28 (1.6)	27.1 (1.7)	28.2 (1.2)	$t(48) = -2.7$	$p = .01$[a]*
RSPM	50 (7.7)	49.1 (7.5)	49.9 (8.1)	$t(48) = -0.4$	$p = .73$[a]

* significant at .05
[a]Independent samples *t*-test.
[b]Pearson Chi-Square with Continuity Correction
Att Training = training on attention tasks; WM Training = training on working memory tasks; MoCA = Montreal Cognitive Assessment; RSPM = Raven's Standard Progressive Matrices.

At the conclusion of the data collection phase of the study, a summary of experimental results was provided via email to each participant as feedback after primary data analysis was complete.

Laboratory Apparatus and Measures

Participants performed computer-based testing tasks at the laboratory at Time1, Time2 and Time3, and computer-based training tasks at home on their own computer. All laboratory computer-based tests were carried out on a Dell Optiplex 780 running Windows XP SP3 with a standard keyboard and mouse and a 15-inch ELO touch screen monitor with 1024 x 768-pixel screen resolution and a refresh rate of 60Hz. The touch screen fulfilled the specifications for the UFOV® Test and all participants had the option to use the touchscreen or mouse. In accordance with UFOV® requirements, participants were positioned 50cm from the monitor.

Questionnaires and Assessments

Driving attitude and confidence were measured using three self-report questionnaires: Manchester Driving Behaviour Questionnaire (DBQ; version as described in Parker, McDonald, Rabbitt, & Sutcliffe, 2000); the Driving Skills Questionnaire (White et al., 2011); and the Self-Rating Hazard Perception Questionnaire (Conlon & Herkes, 2008). The DBQ consists of 24 items representing driving behaviours categorised into Errors, Lapses and Violations. The instrument asks how frequently events occur. Examples of Error questions include: "*On turning left, narrowly miss a cyclist who has come up on the inside*"; and "*Failure to notice a pedestrian crossing on turning into a side road*". Lapses include questions such as "*Forget where you left your car in a car park*" and "*Realise you have no recollection of the road along which you have been travelling*". Violations include questions such as "*Angered by another driver's behaviour, you give chase with the intention of giving him/her a piece of your mind*" and "*Drive especially close to signal the driver in front to go faster/get out of the way*". Responders indicate by way of a six-point

Likert scale ranging from Never (0) to Nearly all the time (5). Low scores indicate fewer self-reported incidents in each category.

The Driving Skills Questionnaire has 11 items scored on a four-point Likert scale. For items relating to events that occur when driving such as "*How often do you misjudge the distance to stop to avoid colliding with another vehicle?*", the response type was Often (3), to Never (0). Responses to items that relate to self-perceptions such as "*What level of stress does driving in heavy traffic cause for you?*" ranged from Very High (3) to Very Low (0) with reverse scoring where appropriate. Lastly, for items of perceived difficulty, such as "*Judging the speed of oncoming vehicles is…*", responses ranged from Extremely Difficult (3) to Not at all Difficult (0). A low overall score on the Driving Skills Questionnaire indicates a self-perception of little or no difficulty while driving, whereas a high score indicates a perception of frequent difficulty when driving (Conlon & Herkes, 2008).

The Self-Rating Hazard Perception Questionnaire is made up of six items that rate the participant's ability to detect various hazards, as compared to the skill of other drivers the same age. An example of the questions includes "*Compared to other drivers your age, how skilful are you at spotting hazards quickly?*". Responses are scored on a Likert scale ranging from Much Less (1) to Much More (7) with low scores indicating a perception of very low ability and a high score indicating a perception of a much greater ability than other drivers of the same age.

Cognitive performance was measured with the MoCA (Nasreddine et al., 2005) which is a test of cognitive function frequently used to detect mild cognitive impairment and early Alzheimer's disease. The MoCA measures attention, executive function, memory, language, visuo-construction skills, calculation, and orientation, and has a maximum achievable score of 30 with scores below 26 suggesting mild cognitive impairment (Nasreddine et al., 2005). In this group MoCA scores ranged from 24 to 30 (M = 28, SD = 1.58). A score of 26 or above suggests no cognitive impairment however, in this sample, one participant scored 24 and four scored 25 (refer to Table 3.1). No participant was excluded because of his or her score as overall results in all other tests were within the normal range, so their data was retained.

Problem solving and intelligence were measured using Raven's SPM (RSPM; Raven, 2000). RSPM is a non-language-based test of IQ with norms for older adults. Specifically, RSPM has been highly correlated with other tests of intelligence and is considered a reliable indicator of Spearman's General intelligence (Spearman's "g"; Snow, Kyllonen, & Marshalek, 1984). Specifically, RSPM is a visual test directly accessing problem solving and reasoning and thus is thought to be more in line with driving as a visual activity. Each participant attempted all 60 items and administration was not time limited. Maximum score achievable is 60 and a score of 45 represent the 50th percentile. A score of 55+ represents the 95th percentile for adults 68 years old and above (Strauss, Sherman, & Spreen, 2006). In this group scores ranged from 32 to 60 (M = 50, SD = 7.7: refer to Table 3.1).

In order to ensure testing-related anxiety did not confound performance (Mella et al., 2020), and to manage any participant concerns over doing new tasks, a small sample of 19 participants completed a measure of test-anxiety prior to each data collection session. The measure was a Visual Analogue Scale (VAS) with a 100 mm line anchored at one end with the word "Calm" and at the other with the word "Anxious". The questions asked on the VAS were: *"How are you feeling about doing the computer-based tests? In general? The Visual Search task (red square)? The Useful Field of View test?"*. Participants completed the VAS prior to each data collection session and marked the line in accordance with their feelings when anticipating the tasks. Because this measure was included to address any concerns prior to testing, this data was not included in the analysis.

Laboratory-Based Computer Tasks

Visual search and reaction time were measured via a conjunction search task. This task commenced with a white fixation cross centred on a black background. The cross remained on the screen for the duration of all trials, however participants were instructed to move their eyes to search for the target. The target was a red square (8mm side; 0.92° x 0.92°; refer to Figure 3.3) which replaced one red circle in a display of equal numbers of red circles (8mm diameter; 0.92° x 0.92°) and green squares (8mm side; 0.92° x 0.92°). There were three display sizes of 4, 10 or 20 objects all randomly positioned within the display. The experimental block comprised 72 trials made up of 24 trials of each display size (50% with the target present) randomly allocated in the block. Participants were given a verbal explanation along with on-screen instructions, then had two practice trials before they completed the 72 experimental trials. Response was a two-alternative-forced-choice using the “a” key if the target was absent and the “p” key if the target was present. Participants were able to rest their finger on each of the keys in readiness for their response. The display remained available until the participant responded, however instructions directed participants to respond as quickly and accurately as possible, as speed and accuracy were of equal importance. At the conclusion of all experimental trials, accuracy (as a percentage) and average reaction time appeared on the screen as feedback.

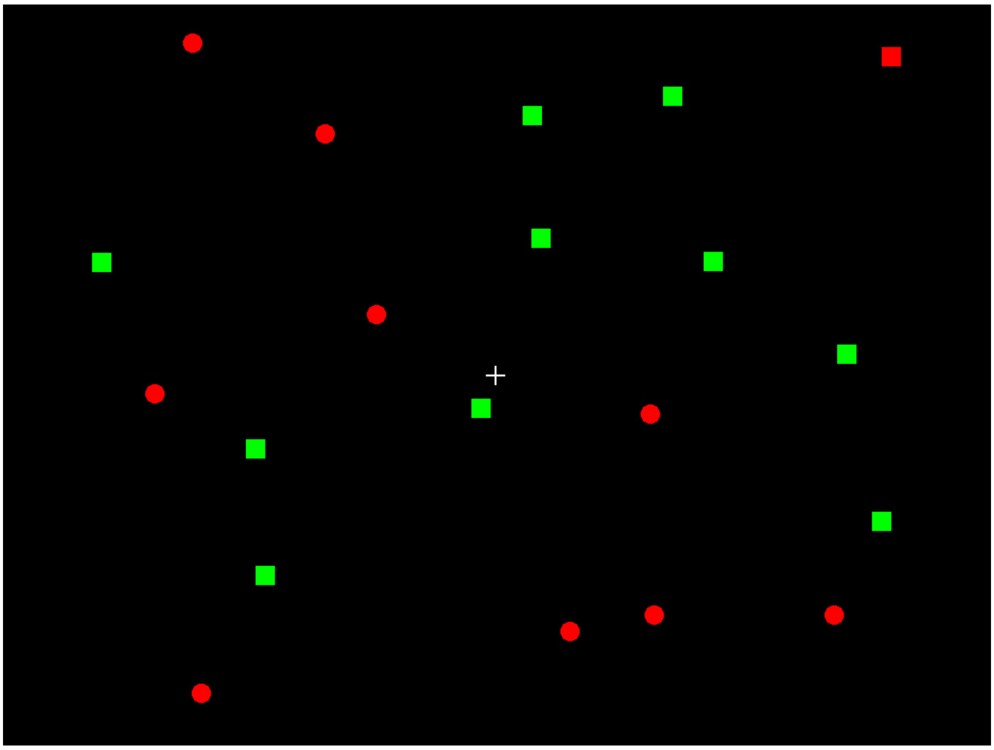

Figure 3.3. Conjunction search task with 20 objects; 19 distractors (green squares and red circles) and target (red square).

Useful Field of View Test (UFOV) comprises three computer-based tasks that progressively increase in complexity and difficulty. The three tasks are completed in the same order each time (see Figure 3.4). Each task generates a score in milliseconds based on a double staircase method with varying stimulus duration. Threshold is set at 75% accuracy and the task continues until threshold is reached, so trial numbers vary across participants. A low score indicates a faster reaction time. The Useful Field of View – Processing Speed (UFOVPS) task is an object discrimination task where the participant determines if the white object, presented in a box at fixation on a black screen, is a car or a truck. The Useful Field of View – Divided Attention (UFOVDA) task requires that the object discrimination task be repeated, but this time while simultaneously locating a second object (a white car) from one of eight radial positions in the periphery. The Useful Field of View – Selective Attention (UFOVSA) task, again builds on previous tasks, but this time the simultaneous identification and location tasks are made more difficult with the addition of 47 white triangles the same size and luminance as the targets. In all tasks, a patterned mask follows each presentation, and the response is by touch screen or mouse indicating either the car or truck as the central object, and then touch or click on the location of the periphery object. Because the reaction time for each trial was controlled via the stimulus duration, this response was not timed.

a) **b)** **c)**

Figure 3.4. Stimuli from UFOV Test: a) UFOV Subtest 1 - Processing Speed, b) UFOV Subtests 2 – Divided Attention, c) UFOV Subtest 3 – Selective Attention.

Home-Based Training Tasks

All participants were assigned to one of two training conditions either Attention (Att) or Working Memory (WM). Each condition included three training tasks, to complete daily on the participant's home computer for 14 consecutive days, between Time2 and Time3. All training tasks were matched for timing and difficulty with the base-line tasks, and each programmed using INQUISIT software version 3.0.6.0 (Inquisit, 2011). Each home-based training session took between 15 and 20 minutes to complete.

Attention Condition Tasks

Training tasks for the Att condition were designed to tap into processing speed, choice reaction time, sustained attention, and visual search, each being attention tasks specific to activities of daily living, especially driving (Cosman, Lees, Lee, Rizzo, & Vecera, 2012b; Halperin, Sharma, Greenblatt, & Schwartz, 1991; Pammer & Blink, 2018; Rabbitt, 2017; Tabibi, Borzabadi, Stavrinos, & Mashhadi, 2015). The training tasks therefore included two visual search tasks, those being firstly the same conjunction search task administered at baseline (see Laboratory-based computer tasks), plus a speeded visual search task with a covert attention component, and lastly, a conditional sustained attention task. Details of each of the selected training tasks, plus justification for inclusion, is as follows:

Conjunction search task. Visual search and reaction time decline with age (Plude & Doussard-Roosevelt, 1989; T. A. Salthouse, 1996). The more effortful requirements of identifying and separating features in conjunction search and selective attention become more difficult with age, and older adults tend to take longer to correctly respond to these stimuli (Foster, Behrmann, & Stuss, 1995). The age-related impairment in conjunction search has been attributed to a combination of neurological changes and a pragmatic and/or compensatory response style. For example, Ratcliff, Spieler, and McKoon (2000) suggested that response times are longer in visual search tasks where older adults need to make a decision because of a speed-accuracy trade-off. This theory is similar to that of Hommel, Li, and Li (2004) who observed that older adults generally maintain a consistent search efficiency, but conjunction search performance declines more than for younger subjects when the number of distractors increases, and even more so when the target is absent (although see Foster et al. [1995] who found no difference in errors and omissions across an old and young sample). Cosman et al. (2012b) found that those participants who performed poorly on the UFOV also performed significantly worse on conjunction search (while maintaining performance in feature search) suggesting performance was impacted by longer dwell times and longer times to shift attention from one object to another. Accordingly, it was decided to include conjunction search as an effective training task to transfer to UFOV performance (refer to Laboratory-based computer tasks above for a description of the conjunction search task).

Speeded visual search task. This task was designed as an attention-demanding visual search task with a single target among seven highly similar distractors to firstly eliminate pop-out effects (Huang & Pashler, 2005), and secondly to increase attentional engagement by using a large set-size and a visually difficult search task (Ester, Fukuda, May, Vogel, & Awh, 2014; Han, 2017). This training task was included specifically to match the difficulty of UFOVSA but also, with training, to extend the limit of participants' attentional capacity. As such, against a grey background, the display commenced with a central cross, overlaid with an X that created an eight-arm star fixation point. In each trial, the participant hit the "Enter" key which started the task. Eight black/white static Gabor patches arranged in a circle (radius 110mm from fixation), were presented on the screen for 200ms. Each Gabor patch had a 37mm Gaussian envelope, a frequency of 0.06 cycles/pixel and was vertically oriented (180˚). On 50% of trials, one of the Gabor patches was replaced by a target, which was identical to the distractors except the frequency was increased to 0.08 cycles/pixel resulting in a higher frequency image, and although difficult to detect, pilot testing indicated that overall performance was better than chance (Figure 3.5). The target would appear randomly at any of the eight radial positions. As in the conjunction search task, participants responded with the "p" key if the target was present or the “a” key if the target was absent. Either response generated the recording of accuracy and time taken to respond and then started the next trial. At the commencement of the task, participants viewed a demonstration and completed two practice trials before completing the 36 experimental trials.

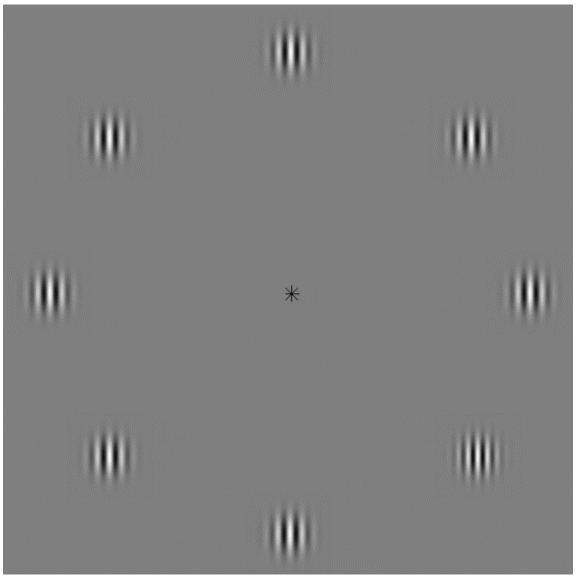

Figure 3.5. Speeded visual search task, target bottom right.

Conditional continuous performance task. This task was based on that described in Cohen, Barch, Carter, and Servan-Schreiber (1999) which was a continuous performance task (CPT) developed to assess the attentional deficits of those with schizophrenia. Notably, a version of this task was later identified as an effective cognitive training task for those with acquired brain injury and for older adults (Van Vleet et al., 2016), with the authors concluding that their version of the CPT was directly targeting attention and executive function in their participants. Similarly, the version of the CPT used in the current experiment included the sustained attention component where the participant had to continuously monitor a stream of letters for a given target (X), as well as having to watch for the conditional condition (the letter A before the target X) before responding, effectively adding complexity with a go/no-go component. As per these types of sustained attention tasks, this visual task requires considerable focused mental effort that, in turn, puts a substantial demand on attentional resources (Warm, Parasuraman, & Matthews, 2008).

A stream of upper-case letters (15mm x 15mm; 1.7°) were presented one by one for a period of around nine minutes (times varied due to response variations). Participants responded by pressing the spacebar whenever an X appeared on the screen but only when an A preceded the X (refer to Figure 3.6). All letters in the English alphabet were included with the addition of three As, plus six A-X sequences, totalling 35 target events. The letters and A-X sequences were randomised and repeated 50 times, with each stimulus remaining until response (maximum 920 ms), with a 230 ms ISI between each letter presentation (refer to Figure 3.6). Accuracy, error events, and response time were recorded. No feedback was given on this task.

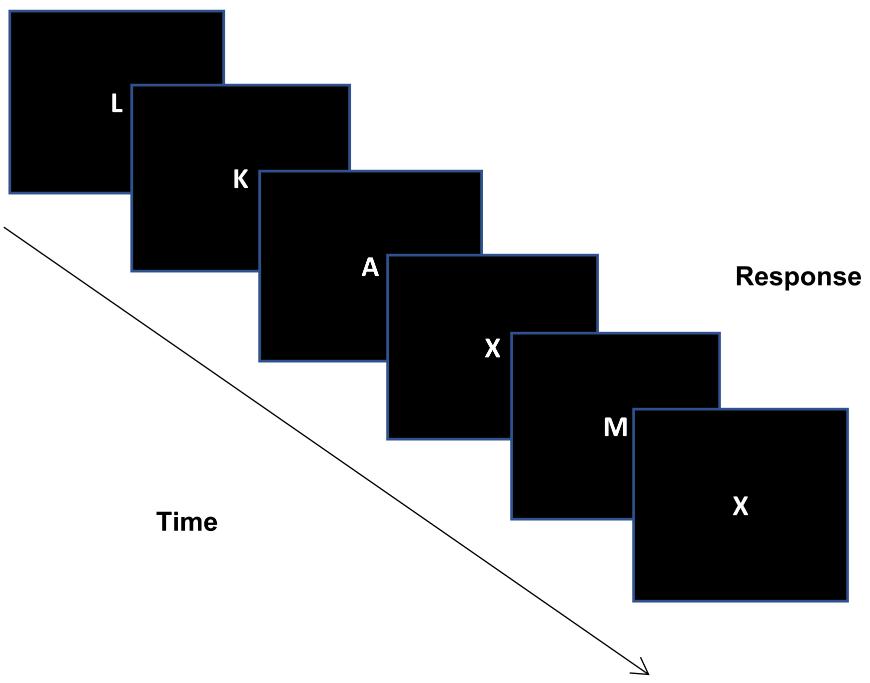

Figure 3.6. Schematic of conditional continuous performance task. Response (space bar) every time an X appeared but only when preceded by an A.

Working Memory Tasks

Training tasks for the WM condition included a computer-based Blackjack card game, Digit-Span-Forward and Backward, and a visual estimation task all of which were variations of those on the Inquisit task library (www.millisecond.com).

Black-Jack game. Card games have been identified as a mechanism for preservation and maintenance of memory skills, particularly working memory (Jonaitis et al., 2013). Therefore, this task was chosen as an on-line version of a common card game that is relatively easy to learn, but requires some level of information retention during the game. Two cards, randomly selected from the 52 available in a standard deck of playing cards, were displayed on the screen and represented the participant's hand. The aim of the game was to draw cards from the deck with a face value that added to 21 or as close as possible without exceeding 21. After viewing their first two cards, the participant was prompted to nominate if he/she would draw another card or elect to stay with the cards he/she had. If the player opted to take another card, the value of the additional card was added to the total of those already dealt. If the value of the cards exceeded 21, the participant lost the hand. If the total did not exceed 21, the process continued until the participant either lost the hand or chose to stay. If he/she chose to stay, the dealer (program) would be dealt two cards from the same deck and would independently make the same choices based on reaching, but not exceeding the face value of 21 - the algorithm prevented the dealer from drawing over 21. If both the dealer and the participant's card value was below 21, the hand with the score closest to 21 won the hand. Although the cards remained in view, participants had to retain the sum of their card face values in working memory as they made their decisions and made comparisons with the dealer's cards. The activity was untimed. Participants played ten games before moving on to the next task.

Digit-Span-Forward and Backward. Digit-Span-Forward and Backward is a test of working memory span (Lezak, Howieson, & Loring, 2004) with performance in both digit-span forward and backward reported to decrease with advancing age (Babcock & Salthouse, 1990; Hester, Kinsella, & Ong, 2004). A series of randomly selected digits between 1-9 were presented sequentially for 1000ms with an ISI of 1000ms. After the last digit, a box appeared on the screen so the participant could enter their response. In the forward version, participants typed the digits in the same sequence as presented into the response screen after presentation of the final digit. The series span started at three digits and would increase by one digit after every correct trial. There was no increase in span after an incorrect trial, but a consecutive incorrect trial would reduce the next trial by one digit. The maximum span available was 14 digits and 14 trials each of forward and backward were completed. In the backward version, the task had the same presentation, but the response differed in that the sequence was typed in backward order after presentation of the final digit. Participants were instructed that they could develop any technique, such as rehearsal, to assist their performance, however instructions explicitly excluded writing down or recording the numbers. After the final trial of both forward and backward, the maximum span correctly recorded, and the most consistently correct span length was displayed as feedback.

Visual estimation task. The stimuli for this task was adapted from a dot estimation task which is a simple visual exercise requiring the estimation of the number of dots presented on the screen. Dot estimation accesses long-term and working memory and has been used when comparing strategy selection and performance of young adults, older adults, and those with probable Alzheimer's disease (Gandini, Lemaire, & Michel, 2009; Tuholski, Engle, & Baylis, 2001). The task comprised 11 randomly-presented displays of yellow dots (RGB 252, 244,3) on a blue background (RGB 72, 66, 245). Each display had between 26 and 88 dots in varying configurations and was presented for 1000ms followed by a blank blue screen (refer to Figure 3.7. There was no mask. The participant would enter his/her estimation of the number of dots after each display, which would trigger the next trial. The expectation (which was confirmed during pilot testing) was that participants would use a benchmarking strategy where participants retain previous images in visual working memory and base their response on a comparison of that visual memory (Gandini et al., 2009). No feedback was provided for this task.

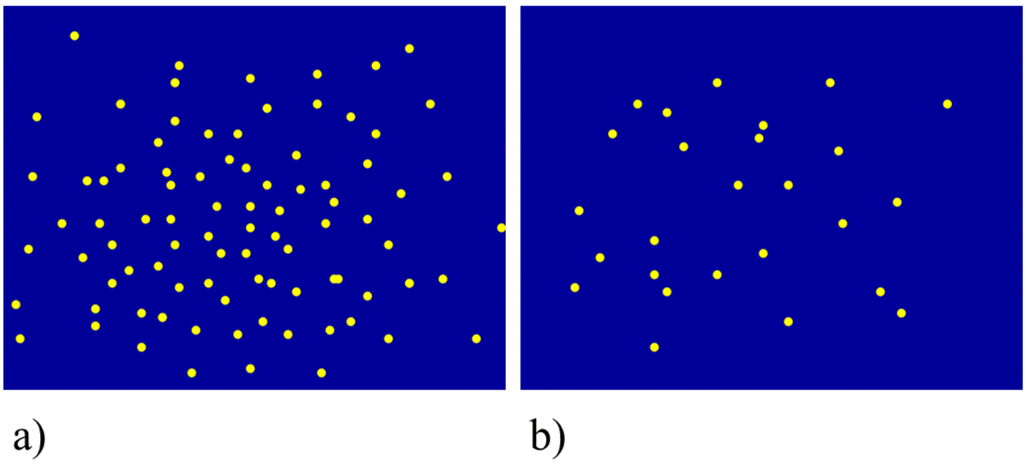

Figure 3.7. Example of presented stimuli for Visual Estimation task. a) Maximum b) Minimum

Initial Analysis and Results

To avoid repetition, the results that are common to all conditions, such as demographics and pre-intervention analyses, are presented in this chapter. Otherwise, results specific to each experiment are detailed in the relevant chapter.

Inspection of the time- and date-stamp data recorded when participants logged into the program and completed the allocated training tasks indicated that participants completed the majority of the daily home-based training session; overall average completion rate of 88% of the 14 sessions (M = 12.37, SD = 2.77). There was no difference in compliance between the Att (M = 12.43, SD = 3.0) and WM groups (M = 12.25, SD = 2.63), $t(48) = .225$, $p = .82$. This was supported by diary entries that also indicated satisfactory compliance.

As noted earlier two data sets were combined to make best use of the available data. Twenty-six participants completed the 14-day no-activity control period between Time1 and Time2, and then went on to complete the home-based training, followed by Time3 (WithControl). Data for 24 participants who completed the home-based training after their first lab session (Time2) without completing the control period (NoControl) were also included in the analysis. All participants from both groups completed the home-based training component resulting in a total of 50 participants who completed the intervention (refer to Figure 3.2 and 3.2a).

Differences between groups and practice effects

As data were collected across two different designs, two comparisons were made. Firstly, scores on all baseline tasks were compared to ensure there were no differences between the two groups. The results indicate there was no significant difference in most of the measures when participants first did each test (Table 3.4), except in years driving. Although this difference was significant, because both groups averaged over 50 years driving experience, the difference was not considered important, and so was noted but did not impact on any further findings. However, an independent-samples t-test was conducted to compare the average threshold scores at Time2, which was the first time the NoControl participants had exposure to the laboratory-based computer tasks, but the second exposure for the WithControl group (refer to Table 3.5). Although there was no significant difference between groups for the conjunction search task (CSRT & CSAC), it can be seen in Table 3.5 that there was a significant difference in each of the three UFOV tasks between the WithControl and NoControl groups at Time2 (UFOVPS: $t(48) = 2.05$, $p = .05$; UFOVDA: $t(48) = 2.03$, $p = .05$; UFOVSA: $t(47) = 2.48$, $p = .02$). The significant improvement from Time1 to Time2 on the UFOV tasks may be interpreted as a simple practice effect, and/or that participants became more familiar and more comfortable with the task over time. This is supported by the observation from the 19 participants who completed a Visual Analogue Scale (VAS) as part of an exploration of participants' reaction to the computer-based testing – particularly the UFOV test. It was noted that participants' responses had significantly shifted from "Anxious" (M = 44.6 mm on a 100 mm scale) toward "Calm" (M = 29.4 mm) on a Visual Analogue Scale from Time1 to Time3: $t(14) = 2.294$, p = .038. It should be noted that the significant difference in UFOV scores at the start of the intervention was important but will not be discussed here. The significant improvement from Time1 to Time2 will allow the authors to analyse the impact of the intervention over and above this learning effect and will be discussed in each subsequent relevant Chapter 4 and 5.

Table 3.4. Independent t-test Results Between Participants With a Control Period and those Without a Control Period at Commencement (Time1)

	Time1 Mean (SD)			
	WithControl (n = 26)	NoControl (n = 24)		
UFOVPS (ms)	34.42 (30.58)	22.53 (12.37)	$t(48) = 1.88, p = .07$	
UFOVDA (ms)	103.37 (101.99	78.48 (93.97	$t(48) = 0.90, p = .38$	
UFOVSA (ms)	261.97 (122.29)	239.94 (111.87)	$t(47) = 0.66, p = .52$	
CSRT (ms)	1631.01 (416.61)	1571.93 (331.44)	$t(47) = -0.54, p = .60$	
CSA/c (%)	94.69 (3.19)	94.97 (2.46)	$t(47) = -0.34, p = .74$	
Age (yrs)	74.65 (6.62)	72.22 (8.16)	$t(48) = -1.16, p = .25$	
Education (yrs)	16.29 (3.21)	15.59 (3.25)	$t(48) = -0.77, p = .45$	
MoCA	27.54 (1.77)	27.86 (1.32)	$t(48) = 0.72, p = .47$	
RSPM	51.14 (6.06)	47.41 (9.09)	$t(48) = -1.74, p = .09$	
DBQ	17.96 (7.27)	19.32 (8.35)	$t(48) = 0.61, p = .54$	
Hazard Perception	26.79 (5.21)	28.27 (5.85)	$t(48) = 0.95, p = .35$	
Driving Skills	12.75 (4.43)	12.00 (4.53)	$t(48) = 0.59, p = .56$	
Years Driving	56.46 (7.91)	50.71 (8.90)	$t(47) = -2.39, p = .02$	*
Klms driven then	17420 (12639)	17319 (11943)	$t(47) = -0.03, p = .98$	
Klms driven now	10497 (7379)	14925 (10685)	$t(47) = 1.72, p = .09$	
Accidents last 5 yrs	0.39 (0.63)	0.10 (0.44)	$t(47) = -1.86, p = .07$	

Note: UFOVPS = Useful Field of View Task 1 – Processing Speed; UFOVDA = Useful Field of View Task 2 - Divided attention; UFOVSA = Useful Field of View Task 3 – Selective Attention; CSRT = conjunction search reaction time; CSA/c = conjunction search accuracy; MoCA = Montreal Cognitive Assessment; RSPM = Raven's Standard Progressive Matrices; DBQ = Manchester Driver Behaviour Questionnaire; Klms driven then = average kilometres driven per year during years prior to retirement; Klms driven now = average kilometres driven per year now.
* $p < .05$

Table 3.5. Comparison between NoControl and WithControl laboratory-based test results at the commencement of training intervention (Time2)

	Group	*M (SD)*	*T*	*df*	*p*
	NC	1567.64 (332.77)			
CSRT (ms)	WC	1554.31 (345.65)	0.14	47	.89
	NC	94.78 (2.32)			
CSAC (% correct)	WC	94.15 (4.43)	0.59	47	.56
	NC	33.81 (30.80)			
UFOVPS	WC	20.87 (11.45)	2.05	48	.05*
	NC	105.64 (101.62)			
UFOVDA	WC	56.58 (69.22)	2.03	48	.05*
	NC	254.33 (115.42)			
UFOVSA	WC	186.82 (75.05)	2.48	47	.02*

Abbreviations: NC = NoControl group; WC = WithControl group; CSRT = conjunction search – reaction time; CSAC = conjunction search accuracy; UFOVPS = Useful Field of View Processing Speed; UFOVDA = Useful Field of View Divided Attention; UFOVSA = Useful Field of View Selective Attention.

Analysis

Multilevel linear modelling (MLM) was used for analysis for several reasons. Firstly, repeated measures frequently result in violation of the independence of variance assumption. This is because each data point is recorded from the same participant over time and is therefore related to other data points from that same participant when he/she repeats the task (Tabachnick & Fidell, 2007). Although MLM is often used when participants are grouped in ways that create similarities within the group (such as classrooms or clinics) collecting data from the same participants over time creates a similar grouping effect, except it is the individual who creates the similarities. Data taken from each individual at each retesting occasion is more similar to that from the same individual than it is to other individuals in the same study. Therefore, longitudinal data violates the test of independence of all observations. This within-subjects correlation is measured via the intra-class correlation (ICC) which is the ratio of between-subjects variance over within-subject variance (Tabachnick & Fidell, 2007) and indicates the proportion of variance attributed to the data coming from the same group over time, compared to the total variance (results in a proportion score between 0 and 1). If the result is close to zero, there is not much variance attributable to each repeated data point and so, independence is assured and an analysis method, such as repeated measures ANOVA, is appropriate. However, the closer the ICC gets to 1, the more variance is attributable to the repeated measures, and the more dependence on the data. Because MLM does not rely on the assumption of independence of error and variances, MLM is an appropriate analysis method when the ICC gets closer to 1. The ICC scores are reported in each analysis in this thesis; however it is noted that all scores were generally around the mid-range. Two things can explain this: the dependence of each data point because of repeated measures which pushed the ICC score closer to 1; plus the greater variability in performance scores for older adults when doing higher order cognitive tasks compared to younger adults (Haynes, Bauermeister, & Bunce, 2017), which then brings the ICC score closer to zero. This is discussed further in each relevant chapter along with the specific results.

Lastly, MLM effectively manages uneven and mixed design complexities; MLM does not require equal numbers of cases in each group, nor does it require equal time between testing occasions (Quene & van den Bergh, 2004; Tabachnick & Fidell, 2007). In this dataset, there are 26 participants who completed the control condition plus there are data for 50 participants in the intervention condition (26 in the Control condition and 24 in the NoControl condition). If general linear modelling (GLM) was used to analyse this data set, (repeated measures ANOVA), listwise deletion would result in a significant number of complete data sets being excluded (the 24 participants in the NoControl condition who did not complete Time1). This would create bias and reduce power in the analysis. However, because MLM manages uneven sample sizes using a process of calculations from all other available data points, analysis is completed without the need for imputation or loss of statistical power (Quene & van den Bergh, 2004). MLM uses an iterative process to estimate any missing data points using two stages: firstly, the fixed parameters are calculated (Time) using all available data points; then by the same process, any required random parameters (participants) are calculated. Next, these parameters are estimated repeatedly using the results of the previous estimations. These repeated processes build into what is referred to as the maximum likelihood estimate for each data point (see Quene & van den Bergh, 2004 for a more thorough explanation). MLM assumes data points are Missing at Random rather than Missing Completely at Random, so comparisons between groups on all parameters were compared prior to further analysis (Table 3.5).

All the above reasons mean that MLM allows full analysis of the available data without the loss of any data by listwise deletion and it does not distort the error variance of the data set, which are both characteristics typical of longitudinal designs (Bryk & Raudenbush, 1992; Sliwinski & Buschke, 1999). In summary, because of the repeated measures design, plus the combination of the two data sets resulting in an uneven design (26 data points in the control condition [Time1 to Time2], and 50 for the experimental condition -Time2 to Time3), hierarchical analysis and MLM were the most appropriate statistical method to use for analysis in Chapters 4 and 5. Further, due to the relatively small sample size, Restricted Maximum Likelihood Estimation (REML) was appropriate (Kenward & Roger, 1997) and applied in each analysis. A two-level hierarchical model assessed the effects of training type (Att or

WM training) on all scores. First level units were condition (Att or WM at all Times) and second level units were the 50 participants.

All data were analysed using the Statistical Package for the Social Sciences (SPSS: Version 22). As all comparisons were planned, an alpha of .05 was used for all analyses.

Due to program failure, one participant's results for both conjunction search reaction-time and accuracy (CSRT and CSAc) and another participant's results for UFOVSA failed to record, resulting in only 49 data points for these measures at Time1. All other data anomalies are recorded in each relevant chapter.

UFOV – Processing Speed Results

The authors describe the UFOVPS as accessing object discrimination and central vision and requires the participant to determine if the object presented at fixation is a car or a truck. It has been noted that older adults are generally able to perform this centrally-focused task as well as younger participants when there were no other simultaneous visual actions required, other than the central task (Owsley, 2013), and normative data indicates that older participants are generally able to perform at an average speed of around 30ms (*SD* = 41), although the scores in their normative population ranged from the minimum 16ms to the maximum 500ms (Edwards et al., 2006). In the current study, most participants found the task overly easy and so were performing at ceiling (75% accuracy at RT of 16.7ms: 62% Time 1, 70% Time 2 & 85% Time 3). After further investigation, it was found that this result was similar to those found by other authors in comparable populations (e.g: Bentley, LeBlanc, Nicolela, & Chauhan, 2012; Matas, Nettelbeck, & Burns, 2014). Further, when testing the reliability and validity of the PC version of the UFOV Test, the authors noted that UFOVPS scores did indeed have a restricted range and low variability (Edwards et al., 2005), however they recommended the retention of the task in the overall test as an appropriate warm-up prior to the more difficult UFOVDA and UFOVSA.

In the data collected for the current experiment, the removal of ceiling scores for UFOVPS at Time1 resulted in only 11 out of 50 data points remaining overall (seven in the Att condition and 4 in the WM condition). It was therefore decided that no further analysis of UFOVPS results would occur as part of the transfer of training gains study, but the data would be retained for analysis of relationships between the UFOV Test and other variables of interest (Chapter 6).

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Chapter 4: Cognitive Training and Divided Attention

Divided attention requires simultaneous processing from a wide sensory field while engaging or switching across tasks (Kramer & Kray, 2006). For example, when taking notes during a lecture, a student must listen, comprehend, evaluate, sort and write in rapid succession (Bohay, Blakely, Tamplin, & Radvansky, 2011; Piolat, Olive, & Kellogg, 2005). When driving, concurrent events may demand attention at unpredictable times, including events such as responding to other vehicles, avoiding a collision, talking to a passenger, and navigating unfamiliar routes. Even everyday activities, such as cooking while interacting with family members, requires dividing attention between several simultaneous tasks.

Evidence indicates that divided attention proficiency decreases with age (N. D. Anderson et al., 2000; Sekuler, Bennett, & Mamelak, 2000) leading to, among other things, an increased risk of falls (Gaspar, Neider, & Kramer, 2013; Monaghan, Johansson, Torres, Brewer, & Peterson, 2022) and increased crash risk when driving (K. J. Anstey, Wood, Lord, & Walker, 2005; Gaspar et al., 2013; Pope et al., 2020). This decline potentially leads to a significant loss of independence, increasing the risk of social isolation and/or depression for many older individuals (Chihuri et al., 2016; Sanford et al., 2019). While many studies using different paradigms support the finding of age-related decline in divided attention (see Fraser & Bherer, 2013 for a review), the cognitive mechanisms involved are less clear. Degraded performance may be due to: response generation being slower (Hartley, 2001); resolving interference (Kray & Fehér, 2017); cognitive slowing specific to task input/output requirements (Salthouse, 1993); or even a more cautious cognitive approach to multiple task integration (Glass et al., 2000). Ponds, Brouwer, and van Wolffelaar

(1988) suggest other possible explanations, including less efficient executive control due to generalised cognitive slowing. Despite uncertainty around the mechanism of decline, evidence of improvements after cognitive training suggest that targeted training may be a useful strategy to offset the effects of age-related changes in divided attention function (Fraser & Bherer, 2013; Hampstead, Mosti, & Swirsky-Sacchetti, 2014; Kelly et al., 2014).

In terms of addressing the divided attention impairment evident for many older adults, specific cognitive training provides a path to improving divided attention performance, which may then lead to lowering driving and falls risks, and thus maintaining individual independence for longer. As a first step in this direction, the aim of the current study was to identify a number of simple, easily accessible tasks that, with training, could provide improved divided attention performance, via training transfer for a group of healthy older adults. In the absence of directly measuring driving performance, a baseline measure was identified that could act as a proxy for driving.

Baseline Measure - The Useful Field of View – Divided Attention

The Useful Field of View (UFOV) divided attention task (UFOVDA) alone has proven to be effective in discriminating between safe and unsafe drivers. For example, in a comparison of cognitive screening methods used to assess older driver crash risk, Ferreira, Simões, and Marôco (2013) found that UFOVDA was among the best predictors of on-road driving, and Hoffman, Atchley, McDowd, and Dubinsky (2005) found similar predictive power when assessing older drivers on a driving simulator. Among those with mild and severe cognitive impairment, Krasniuk, Crizzle, Toxopeus, Mychael, and Prince (2022) also found that UFOVDA was among the best predictors of pass/fail results in this population. Of note is that

Ferreira et al. (2013) suggested that that UFOVDA may be a beneficial addition to the psychological assessment protocols for evaluating fitness-to-drive in older drivers. Therefore, in the current study, the UFOVDA task was chosen as the measure against which to identify training-related improvements in divided attention, that could also be considered potentially generalisable to driving ability.

Delivering Cognitive Training to Older Adults

As the aim of this study was to improve divided attention functioning as measured by an improvement in UFOVDA performance, it was proposed that training in basic attention tasks would have the greatest likelihood of producing training gains that would enhance general attention functioning. Another important component was using tasks that are ubiquitous in the attention literature that are also easily and freely available outside the university setting, such as games and books. This would mean that, if this online training proved helpful, those wanting to access such tasks for their own ongoing home-based training could find these or similar tasks. A key objective was to have the benefits of training on these basic, accessible attention tasks transfer to performance improvements in the UFOVDA task, a specific driving-related testing task, providing evidence that such training transfer is possible. To support this proposal, a no-activity control period was completed prior to the training intervention (Time1 and Time2). The expectation was that there would be no change in performance in UFOVDA between these sessions. However, after 14 daily blocks of attention-task training, UFOVDA performance would improve, indicating training gain transfer as evidenced by a decrease in reaction time at Time3 compared to Time2 for those completing the attention targeted training (Att group). To further support the efficacy of the attention-based training, a second intervention group was to complete working memory training rather than attention training. For those in the working memory training group, it was expected that performance on the UFOVDA task would remain the same across the three UFOVDA measurements (Time1, Time2 and Time3).

Method

Participants

Prior to participation, content and procedures for the study were explained and then given in writing. All participants gave written consent. Details relating specifically to this chapter are included in this section, as well as a brief general overview of the overall methods, however additional information about the broader study is available in the Methods Chapter.

Fifty community dwelling adults aged 61 to 90 years (*M* = 73.6, *SD* = 7.4) were recruited through poster advertisements, letterbox drops, and advertisements in local newsletters. Of those who responded, 24 were female, all held a current driver's licence, and all drove on a regular basis. Formal education ranged from nine to 21 years (*M* = 16, *SD* = 3.18) and all participants reported normal or corrected-to normal vision (checked within the last two years). As part of the larger study, all participants completed a number of additional assessments and questionnaires. However, because the results are not relevant to this chapter, the results are not included here but can be viewed in the Methods Chapter.

Participants were assigned to either the attention training (Att) or the working memory (WM) conditions, resulting in 25 participants in each group. Scores on the baseline assessments were compared between groups, with the only significant difference between scores for each intervention group being for the MoCA with the Att group scoring significantly lower than the Working Memory group which will be considered as part of the review of results. Refer to Table 4.1 for a summary of demographics, RSPM and MoCA results.

Table 4.1. Summary of participants' demographic information across training conditions

	Total Participants (n = 50) n(%) or mean(SD)	Att Training (n = 25) n(%) or mean(SD)	WM Training (n = 25) n(%) or mean(SD)		
Age	73.6 (7.3)	74.0 (7.1)	73.2 (7.7)	$t(48) = 0.39$	$p = .70$[a]
Sex					
Male	26 (52)	14 (54)	12 (46)		
Female	24 (48)	11 (46)	13 (54)	$\chi^2(2, N = 50)$	$p = .78$[b]
Education	16.0 (3.2)	15.8 (3.1)	16.1 (3.3)	$t(48) = -0.31$	$p = .76$[a]
MoCA	28 (1.6)	27.1 (1.7)	28.2 (1.2)	$t(48) = -2.7$	$p = .01$*
RSPM	50 (7.7)	49.1 (7.5)	49.9 (8.1)	$t(48) = -0.4$	$p = .73$[a]

* significant at .05
[a]Independent samples *t*-test.
[b]Pearson Chi-Square with Continuity Correction
Att Training = training on attention tasks; WM Training = training on working memory tasks; MoCA = Montreal Cognitive Assessment;
RSPM = Raven's Standard Progressive Matrices.

Apparatus and Materials

All participants performed computer-based tasks at the laboratory and computer-based training tasks at home on their own computer. Participants accessed a webpage that linked to the home-based training programs specific to their group (Att or WM).

Laboratory-based Tasks

As a baseline and to detect training-related changes, UFOVDA and a conjunction search task were administered at the three lab sessions (Time1, Time2 & Time3) each 14 days apart. These tests were administered under controlled conditions and took between 15 and 20 minutes to complete. Details of all lab-based and home-based tasks are outlined in the Methods Chapter; however, relevant summary data and images of the tasks are provided in Table 4.1 and Figures 4.1 to 4.5 for reference.

UFOVDA measures divided attention using a staircase method with varying stimulus duration. Performance is measured by the participant reaching a 75% accuracy level which identifies threshold-performance and generates a time score. The task continues until a 75% correct threshold is determined so trial numbers vary across participants. The UFOVDA task consists of an object discrimination task where the participant decides if the object presented at fixation is a car or a truck while simultaneously locating a second object (a car) from one of eight radial positions in the periphery (refer to Figure 4.1). A full description of UFODA is included in the Methods Chapter.

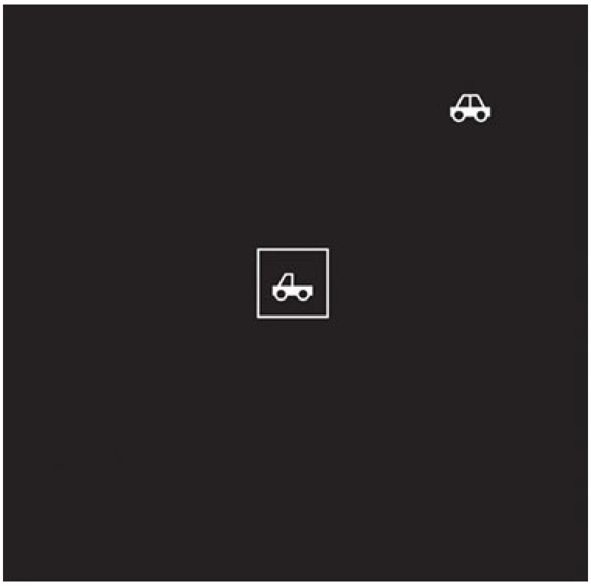


Figure 4.1. Screen shot of UFOV DA task indicating the two decision tasks. Firstly, the object presented in the box at fixation; car/truck? Simultaneously, which of the eight radial positions in the periphery was the car?

Visual search – Conjunction. This task is described in full in the Methods Chapter. A sample of the presentation is at Figure 4.2.

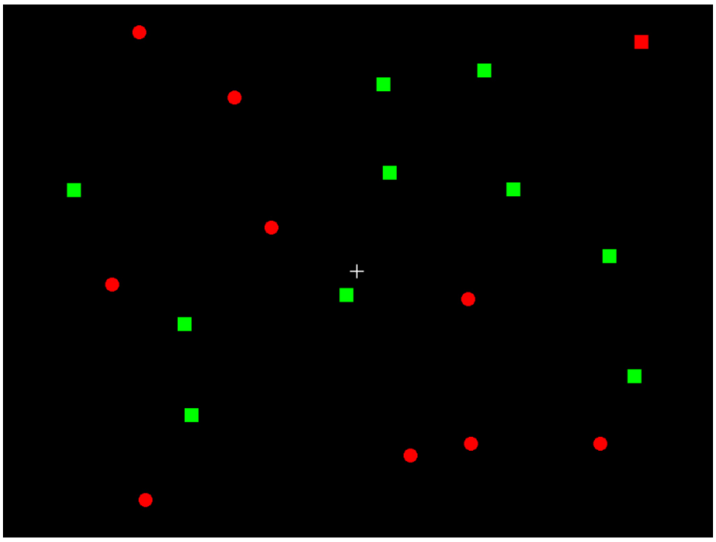


Figure 4.2. Conjunction search task with 20 objects; 19 distractors (green squares and red circles) and target (red square).

All participants were assigned three training tasks, Att or WM depending on which condition, to complete daily on their home computer for 14 consecutive days between Time2 and Time3. Each home-based training session took between 15 and 20 minutes to complete.

Home-based Training Tasks

Attention Condition. The attention training tasks included two visual search tasks (the same conjunction search task administered at base line [refer to Figure 4.2]), plus a speeded visual search task with a covert attention component), and a conditional sustained attention task. Again, each of these training tasks is described in detail in the Methods Chapter but a sample of each is presented at Figure 4.3 and Figure 4.4.

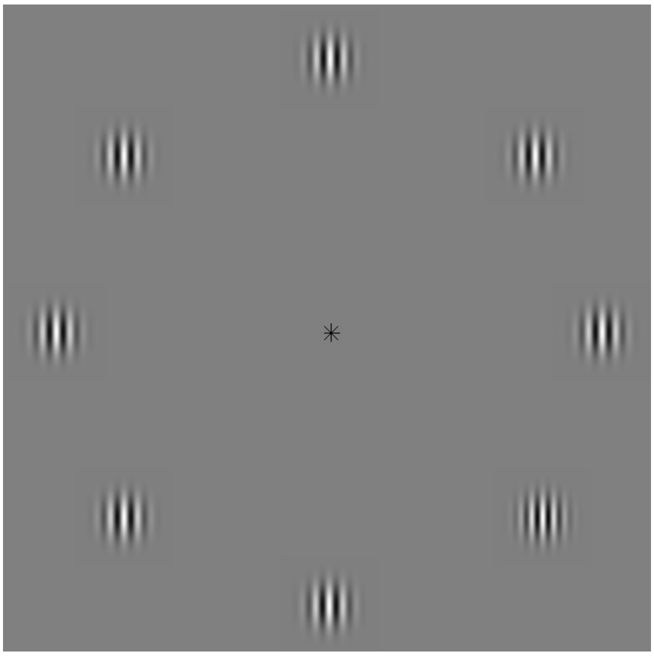


Figure 4.3. Speeded visual search task, target bottom right.

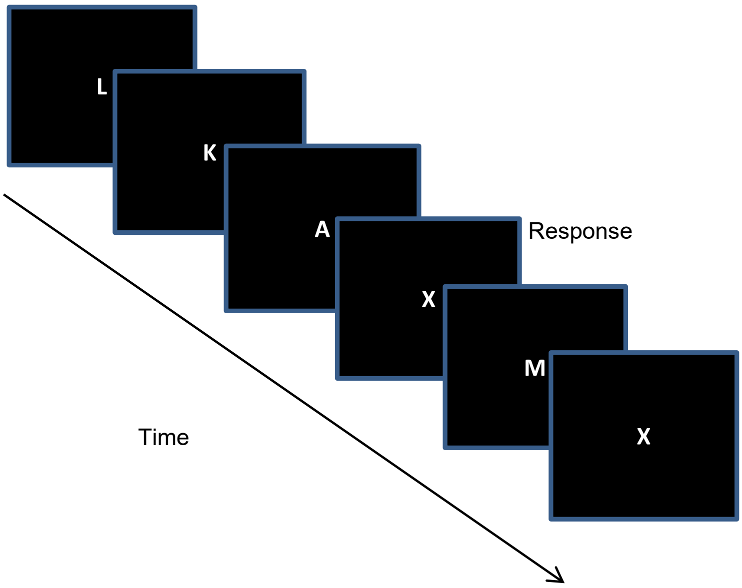


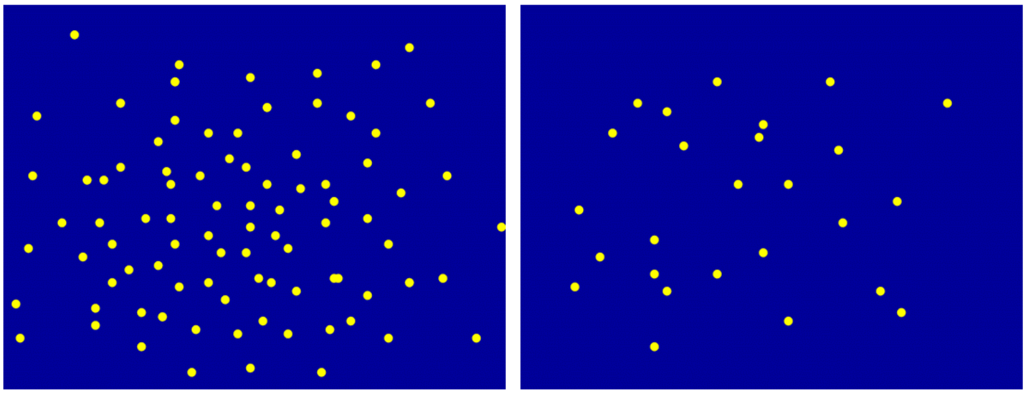
Figure 4.4. Schematic of conditional continuous performance task. Response (space bar) every time an X appeared but only when preceded by an A.

Working Memory condition. Training tasks for the working memory (WM) condition included a computer-based Blackjack card game, Digit-Span-Forward and Backward, and a visual estimation task. Training sessions were completed daily at the participant's home and took between 15 and 20 minutes to complete. Refer to Methods Chapter for a detailed description of each of the tasks included in the home-based working memory training package.

Black-Jack game: This game follows the objective of the card game where the aim is to beat the dealer with either a two card score of 21, a card score below 21 (more than two cards), or if the dealer draws cards with a total value greater than 21. For details of how this game was constructed, refer to the Methods Chapter.

Digit-Span-Forward and Backward: This is a test of working memory span (Lezak et al., 2004). Again, this task is described in detail in the Methods Chapter.

Visual estimation task: This task was designed so that participants would access a working model of previous trials to guide their estimation of each trial. Again, full details of this task is covered in the Methods Chapter and can be reviewed at Figure 4.5.



a) b)

Figure 4.5. Example of presented stimuli for Visual Estimation task. a) Maximum b) Minimum

Procedures

Participants attended three laboratory-based sessions, each 14 days apart, and each time completed the full UFOV test and conjunction search task in addition to other activities relevant to each session.

Results

All data was analysed using the Statistical Package for the Social Sciences (SPSS: Version 22), alpha of .05 was used for all analyses as all comparisons were planned. Data was collected across two waves, firstly 26 participants were included in both the 14-day no-activity control period between Time1 and Time2, and the intervention between Time2 and Time3. Twenty-four additional participants completed the intervention without the control period - Time2 and Time3 only. This group completed the initial assessments and questionnaires at their first visit to the laboratory session. As data was collected across two different designs (those who only completed the experimental condition and those who also completed a control condition), an independent-samples t-test was conducted to compare the average UFOVDA threshold scores for those participants who did not include a control period; NoControl (M = 109.48 ms, SD = 107.11 ms), and those who did include the control period; WithControl (M = 51.31 ms, SD = 65.73 ms), $t(48) = 2.35$, $p = .02$ (refer to Table 4.2). Evident in this result was a significant difference between the UFOVDA scores at the time of commencing the intervention between those who had done the control condition to that of those who did not. It is important to note that this difference was not as a consequence of a practice effect of UFOVDA, despite there being a small improvement (19.62 ms faster) between Time1 and Time2 for the WithControl group as this change was not significant ($t(28) = 1.803$, $p = .08$). As can be noted in Table 4.2, the significant difference prior to the intervention is caused by the NoControl group being, on average, slower at the UFOVDA overall. However, once participants had been allocated to the Att and WM groups, these differences were shared across the two intervention groups, and it is noted that the difference between those groups was not significant (Att: *M* = 102.70 ms, *SD* = 109.67 ms, WM: *M* =60.18 ms, *SD* = 63.88 ms; $t(48) = 1.85$, $p = .07$). Table 4.2 includes all comparisons at commencement of the experiment between control and no-control conditions, and at Time2 between the two training conditions.

Table 4.2. Summary of comparisons across With-Control and No-Control conditions and Intervention conditions

	Control Period (n = 26) n (%) or Mean (SD)	No Control Period (n = 24) n (%) or Mean (SD)	Att Training (n = 25) Mean (SD)	WM Training (n = 25) Mean (SD)		
Age	74.32 (6.66)	72.79 (8.11)			$t(48) = -.73$	$p = 0.47$
Sex						
Male	14 (54)	12 (50)				
Female	12 (46)	12 (50)			$\chi^2(2, N = 50)$	$p = 1.00$[a]
UFOVDA T1	70.93 (85.35) ms	109.48 (107.11) ms			$t(48) = 1.41$	$p = 0.16$
UFOVDA T2	51.31 (65.73) ms	109.48 (107.11) ms			$t(48) = 2.35$	$p = 0.02$*
			102.70 (109.67) ms	60.18 (63.88) ms	$t(48) = 1.85$	$p = 0.07$ⱡ

[a]Pearson Chi-Square with Continuity Correction
UFOVDA T1 = average threshold scores for UFOV Test, Divided Attention task at Time 1 for all participants.
UFOVDA T2 = average threshold scores prior to commencement of training – those who completed a control period were compared with the no-control group.
Att = Attention training group, WM = Working Memory training group
ⱡ Difference between groups n/s as a result of random allocation to groups

As expected, participants completed most of the daily home-based training sessions with an overall average completion rate of 88% of sessions (*M* = 12.37, *SD* = 2.77). There was no difference in compliance between the Att (*M* = 12.43, *SD* = 3.0) and WM groups (*M* = 12.25, *SD* = 2.63), $t(48) = .225$, $p = .823$.

Multilevel linear modelling (MLM) was used for analysis. An interclass correlation of .53 ($F(25,52) = 4.379$ $p < .001$ between Time1, Time2 and Time3 indicated a violation of the independence assumption confirming the appropriateness of hierarchical analysis. Further, due to the small sample size, Restricted Likelihood Estimation (REML) was also appropriate. Therefore, a two-level hierarchical model assessed the effects of training type (Att or WM training) on the UFOVDA scores. First level units were condition (Att or WM) and second level units were the 50 participants.

A random intercept model was found to be significantly better than the fixed effects model $\chi^2(1) = 19.6$, $p < 0.01$. However, including a random slope with the random intercept did not significantly improve the model, so the random intercept only model was retained for further analysis.

Divided Attention

As predicted, there was a significant main effect of Time ($F(2,77) = 7.903$, $p = .001$) across the three testing sessions. However the main effect of condition fell just short of significance ($F(1,50) = 3.832$, $p = .056$) and consequently the two sets of data were collapsed for further analysis. In the combined data, planned comparisons confirmed there was no significant difference between testing Time1 and Time2 (Mean difference = 6.01[13.22], 95% CI = -21.46; 32.00, $p = .67$) supporting the hypothesis of no change in performance during the control period when no home-based training tasks were assigned for either the Att or WM group. However, the planned comparison between testing Time2 and Time3 indicated a significant difference (Mean difference = 39.26[11.37], 95% CI = 17.40; 61.02, $p = .001$), confirming improvements in performance of the UFOVDA task following the 14 days of assigned training for the combined training conditions (refer to Figure 4.5).

Returning to the main effect of Condition (Att training or WM training), due to the result being very close to significant, the difference between training type was examined more closely. Comparisons of UFOVDA performance improvement identified that the Att participants had a significant performance improvement in UFOVDA after training (between Time2 and Time3; $t(22) = 2.074$, $p = 0.016$) and the improvement in UFOVDA results after the WM training was approaching significance ($t(24) = 2.069$, $p = 0.063$). However, the mean difference between the two conditions was not significant (Att: $M = 57.69$, $SD = 105.75$; WM: $M = 18.89$, $SD = 47.42$; $t(45) = -1.635$, $p = .11$. Consequently, the interaction of Time by Condition across the three sessions was also not significant ($F(2,77) = 2.436$, $p = .09$) confirming that the effects of training were not significantly different across the two intervention conditions (refer to Figure 4.5).

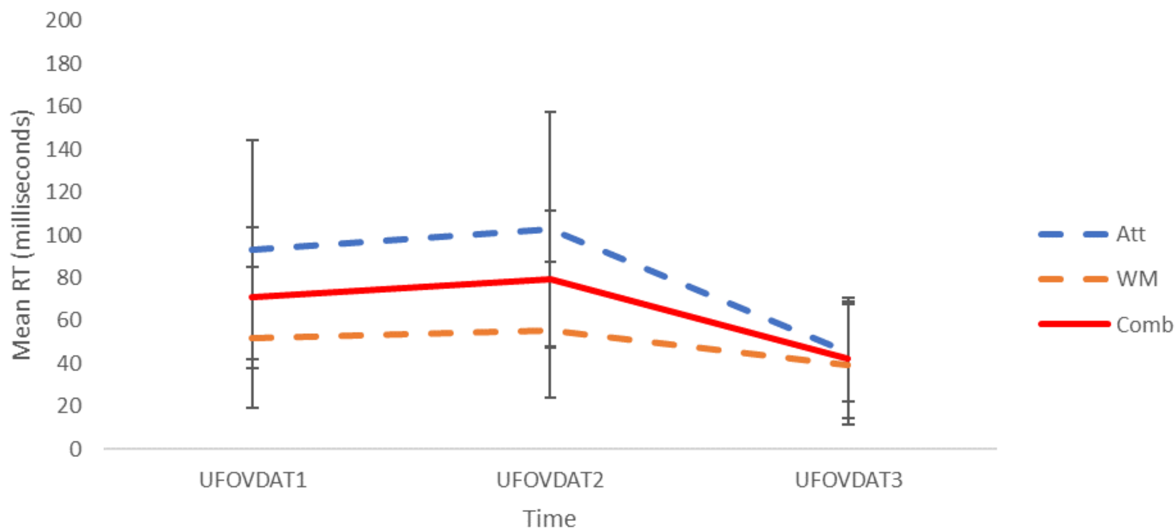


Figure 4.6. Transfer of training gains to UFOV DA (UFOV® divided attention task) as indicated by mean values and corresponding standard error across time. Time1 to Time2 was the no-training control period and Time3 was the outcome after 14 days of Att (attention tasks) or WM (working memory) computer-based training. Due to a nonsignificant interaction between groups, data from both groups was combined and is indicated by the Combined UFOVDA line.

Discussion

Summary of Findings

Of importance in this study is the clear and significant improvement in UFOVDA performance for the combined groups which demonstrates the success and value of daily training on easily available and obtainable attention tasks for an older group. Furthermore, being able to access these training tasks at home on their own computer and in their own time, adds an element of accessibility not usually present in laboratory-based cognitive training regimes.

Although the difference between the two intervention groups was not significantly different, a larger group of participants may firstly replicate these results, but also provide further evidence of transfer of training benefit from cognitive training for the Att group, as well as a clearer indication of the outcome for the WM group. However, it should be noted that although the difference in improvement after training was not significantly different between the Att and the WM groups, those in the Att group did improve in their UFOVDA performance to a greater extent that those in the WM group. In fact, the improvement from Time2 to Time3 for the Att group was significant on its own ($t(22) = 2.616$, $p = .016$) demonstrating far-transfer of the 14 daily sessions of attention training to the UFOVDA task. Once again, a larger participant group would add clarity to the overall result in this study.

It was also proposed there would be no change in performance during the no-activity control period. The importance of this question was firstly to provide a control condition to compare the outcome of home-based cognitive training, and secondly, it was important to rule out practice effects. Independent researchers have tested for possible practice effects in each of the UFOV tasks; specifically, McNamara, John Barr, Bond, and George (2018) reviewed the UFOV test as a repeated measure for the assessment of readiness for an on-road driving test by Occupational Therapists engaged in the rehabilitation of stroke patients. They found that the UFOV test was an effective interim assessment to determine if an individual recovering from stroke was ready for an on-road test. They also noted there were no practice effects detected when the test was administered at one-month intervals (McNamara et al., 2018) which, it is noted, is a longer interval than was applied in the current study. Conversely, in their study looking at UFOV performance of those with glaucoma, Bentley et al. (2012) did find a practice effect for UFOVDA in both their younger control group and their older control group. However, with repeated application, they found that the practice effect disappeared after the second session of the test, thereafter performance levelled out. Looking at the performance of the current participants, it is evident (refer to Figure 4.5) that there was no practice effect apparent after the second UFOVDA assessment for those who did the control period (the WithControl group), and there was an overall significant improvement in performance at Time3 after the home-based cognitive training. This observation very much supports the proposition that in the present study there were no practice effects for UFOVDA experienced by the participants in this group.

Far-Transfer of Cognitive Training Effects

Following 14 daily sessions of attention-task training it was hypothesised that there would be a significant improvement in UFOVDA performance for those in the Att group, indicating far-transfer of training effects. The anticipated benefit of this outcome is the possibility of being able to improve cognitive performance in older people, with the view to this benefit flowing on to instrumental activities of daily living, such as driving. Indeed, the results support the finding of improved performance in UFOVDA as a consequence of transfer of training gains from other trained cognitive tasks.

For those in the working memory-training group it was expected that performance on the UFOVDA task would not change significantly after the training period. Surprisingly, this was not the case. In fact, there was also an improvement in UFOVDA performance after working memory training, again suggesting far-transfer, but not to the extent of the Attention training group, noting there was no significant difference between the two training regimes. These results raise some interesting questions.

Although both conditions demonstrated far-transfer, the improvement after working memory training was smaller in magnitude compared to attention training. Notwithstanding, this outcome in fact signifies greater far-transfer than that for the Att group by representing not a transfer of capability between two dissimilar tasks within the same cognitive domain (attention) but rather from a dissimilar cognitive domain (working memory) to attention, which is a larger step. The UFOVDA loads heavily on attention and processing speed (Ball et al., 2006; Wood & Owsley, 2014) and so transfer from a number of tasks targeting multiple modes of attentional processing, including speeded tasks, is both plausible and was expected. However, the transfer from a collection of working memory tasks was unforeseen but robust (although not significant), indicating a more distant transfer.

Differences Between Groups

Of note is that the Att group's performance at UFOVDA at Time1 was slower compared with that of the WM group (Figure 4.5). Although this difference was not significant (Att: $M = 105.10$, $SD = 12.49$; WM: $M = 52.72$, $SD = 4.03$; $t(27) = 1.56$, $p = 0.13$), the only other notable difference between groups was that of the MoCA scores, again with the Att group MoCA scores being lower than the WM group. In an analysis of the MoCA as a useful driving screening tool, Kandasamy, Williamson, Carr, Abbott, and Betz (2019) found that abnormal MoCA scores (<26) were indicative of a poor fitness-to-drive test result, particularly as the individual grew older. It may be that the lower MoCA scores suggest that on average, the Att group may have been moving into age-related cognitive decline, particularly as there is no difference between groups for education or intelligence (as measured by RSPM). Further, this difference may also reflect that the Att participants had more room to improve and so the cognitive training gave them the boost to regain that lost ground (Almond, 2014; Mitchell et al., 2012). This finding warrants further research regarding opportunities for those with some cognitive impairment benefiting from cognitive training of this kind and provides a good starting point for further research.

Improvement in UFOVDA After Working Memory Training

There have been a few reports in the literature of improvements in attentional functioning after working memory training. For example, a review of working memory training as an intervention for ADHD symptoms concluded that targeted working memory training, under the right circumstances, has the capacity for far-transfer to attention functioning in the ADHD population (Al-Saad, Al-Jabri, & Almarzouki, 2021). Also, Baniqued and colleagues (Baniqued et al., 2014) reported significant transfer to divided attention performance (as measured by improved scores on object tracking, attentional blink and Trail Making) after around 15 hours of playing working memory and reasoning video games in a group of young adults. However, the authors suggested that the games practiced by this group might have loaded on divided attention as each game required tracking multiple items, planning, and coordinated execution during play, and the management of such simultaneous game events might have contributed to improved divided attention outcomes. However, despite using a broad range of targeted video games, the Baniqued study failed to achieve transfer to other cognitive domains with no gains reported in reasoning, memory, or processing speed despite these functions being the target of the training (Baniqued et al., 2014). These results add evidence to the notion that it is difficult to identify the effective component when video games generate training transfer. However, the present experiment identified transfer from common, easily accessed working memory tasks to divided attention function so closer examination of the tasks is warranted.

As described earlier, the working memory training program consisted of three tasks. Because no specific data was collected to analyse the effect of the individual working memory tasks, the impact on attentional resources can only be speculated from the perspective of the culmination of all three tasks: The first task was a non-speeded card game where the participant maintained the sum face value of their cards in memory for the duration of each play; the last was a time-limited dot estimation task where all stimuli were visible for 1000 ms and early trials provided a yardstick against which participants based their estimates (as confirmed by participant feedback after the training period). Each task was selected with the intention of having little demonstrable attention loading but may have, in fact, had an effect on the executive control component of working memory, which does engage a number of attention resources such as response inhibition, vigilance, and set-shifting (Willcutt, Doyle, Nigg, Faraone, & Pennington, 2005), and therefore may have contributed to the transfer effect. Furthermore, the more difficult task in the working memory training set was Digit-Span-Forward and Backward. It appears there is significant disagreement in the literature about whether the Digit-Span test targets attention, working memory, or both (Treviño et al., 2021). In particular, (Lezak et al., 2012) describe both forward and backward tasks as requiring attention and working memory but that Digit-Span-Forward is very much a passive task requiring little mental agility (although see Bowden, Petrauskas, Bardenhagen, Meade, & Simpson, 2013 for an alternate interpretation). However Digit-Span-Backward is considered to be much more difficult, particularly as the task requires holding, then reordering an increasing number of digits in working memory (Lezak et al., 2012). In a recent factor analysis, Treviño et al. (2021) found unequivocally that Digit-Span is a working memory task which did not load with any other neurological tasks within the attention realm of their analysis. Therefore, given that Digit-Span-Backward will have loaded heavily on working memory, it may again have been the engagement of the central executive component of working memory as described by Baddeley and others (Allen, Baddeley, & Hitch, 2014; Oberauer, 2013) that contributed to the far-transfer of benefits to the UFOVDA task for the Working Memory group. In Baddeley's model, the central executive of working memory acts as an attentional controller; essentially a top-down director of attention that is engaged in novel situations when automatic processes are not helpful or not able to be engaged (Baddeley, 2012). In Digit-Span-Backward, each trial is novel and as such, continual attentional control would aid in the task. Having to engage attentional control processes to maintain multiple items in working memory for extended periods may have tapped into divided attention processes and facilitated the transfer to UFOVDA performance.

An alternate but comparable account of an attentional controller in working memory processes is posed in a review by Greenwood and Parasuraman (2016) who present behavioural and imaging evidence in support of their theory behind the mechanism of far-transfer after cognitive training. They argue that the act of maintaining a target in working memory also engages attentional resources that prevent distraction and stop new or competing stimuli from displacing the target. The difference between this and Baddeley's central control is that Greenwood and Parasuraman argue that the role for attentional control is distraction suppression rather than maintaining attentional focus. Potentially both hypotheses could explain the current results simply via the engagement of attention resources in a challenging working memory task, noting that in the current experiment, none of the attention tasks in the attention training set was directly targeting divided attention, yet there was significant transfer to the UFOVDA task, supporting the suggestion that any targeted attention task will flow on to the broader attention function.

A third, and speculative, explanation for the improvement in UFOVDA performance for the Working Memory group relates specifically to Digit-Span-Backward being a difficult task that consequently engages several cognitive resources in addition to working memory. These resources may include sustained attention, focus, reasoning, and possibly language skills. If so, the outcome could be interpreted as one cognitive domain having a positive generalised impact on one or more other cognitive functions as a direct result of the task having a high cognitive load (G. Murphy, Groeger, & Greene, 2016). Although no evidence was found in the literature to directly support such a hypothesis, it could be tested, firstly by replicating these results using the same experimental paradigm as the present study but adding a third condition with a set of complex language and/or problem-solving tasks (to manipulate cognitive load) matched for difficulty with the current attention and working memory tasks, including Digit-Span-Backward, and controlling and comparing performance under differing cognitive load. For example, specifically using verbal rehearsal in the Digit-Span task with eyes open or closed during rehearsal has been found to manipulate cognitive load (Paas & van Merriënboer, 2020). Another example used different types of background music to successfully lessen anxiety in a sample of medical students which in turn, improved performance when learning dissection techniques (Bellier, Secheresse, Stoeckle, Dols, & Chaffanjon, 2020). These examples examine different ways of controlling cognitive load when learning and, as such, the idea that a functionally-specific cognitive load could positively, or negatively, affect other cognitive domains may build on the current findings, plus have exciting application for rehabilitation and general cognitive training for older populations.

Limitations and Future Directions

Further work needs to be done in relation to the longevity of these improvements in divided attention function. A longitudinal extension of this experiment, which follows participants over time and measures the durability of improved performance, would add value to the findings of this study. Additionally, comparisons of durability with maintenance training added at various intervals would also provide evidence as to the utility of the style and delivery of cognitive training for older adults over time. A further practical extension of this study would be direct investigation of transfer of training gains to both falls risk and driving capability. This could be examined at the completion of the training regime and over varying times in the future. As previously stated, UFOVDA is a predictor of falls and driving risk but more importantly, direct training in the UFOV test has been used successfully to improve driving performance for older adults (Ball et al., 2010; Roenker et al., 2003). The current findings, that training with simple, easily accessible cognitive tasks transfers to UFOVDA performance, logically raises the question that such cognitive training tasks, as utilised in the current training regime, may also transfer to actual mobility performance for older adults and so may also directly impact positively on independence.

In summary, the aim of this experiment was to increase performance in divided attention (cognitive functioning) for a group of older adults by way of transfer of training gains from easily accessible, online tasks. Divided attention performance, as measured by UFOVDA, significantly improved after 14 sessions of targeted training in both the Att and WM group compared to the no-training control period. This finding is particularly significant given that divided attention function decreases with age, resulting in increased risk of both falls and of motor vehicle accidents, ultimately leading to a loss of independence for this group. The results of this study have important implications for designing ways that older people can maintain and increase their independence and wellbeing via effective online cognitive training.

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Chapter 5: Cognitive Training and Selective Attention

Driving requires learning a complex set of behaviours. However, once the array of tasks is mastered and the driver becomes more skilled, automaticity takes over and driving becomes seemingly effortless (Charlton & Starkey, 2011). Safe driving is about filtering information and selectively attending to critical events such as the emergence of potential hazards, appearance and changes in road signals and signs, and changes in the environment. As there is so much happening and often at speed, it is impossible for the driver's sensory systems to select and process all information, therefore much of the sensory world when driving is ignored, or filtered out, which is the work of selective attention. Selective attention is the ability to focus on something of importance while filtering out competing but irrelevant information in a cluttered, natural environment (S. Yantis, 2008). As people age, irrelevant or distracting information is more likely to capture their attention, compared with younger observers (Lustig, Hasher, & Tonev, 2001), particularly in a busy, cluttered environment. Selective attention competency declines with age (Dempster, 1992; Rienäcker, Jacobs, Van Heugten, & Van Gerven, 2018) and measurable decrements in general selective attention can be detected in older adults over as little as one to two years, and these changes can indicate an increase in incidence and severity of on-road safety errors (Aksan et al., 2012; Balzarotti, Pagani, Telazzi, Gnerre, & Biassoni, 2022).

Useful Field of View - Selective Attention Deficits and Driving

It has been demonstrated that in older drivers, despite other driving-related cognitive abilities remaining relatively stable (over the two-to-four year testing interval), declining selective attention can lead to significantly poorer performance in driver assessments that subsequently result in the loss of their driving licence, or behavioural restrictions being imposed on driving (Balzarotti et al., 2022). UFOVSA is the third task in the Useful Field of View (UFOV) test and is described by the original authors as targeting selective attention (Edwards et al., 2005; Owsley, Ball, Sloane, Roenker, & Bruni, 1991). UFOVSA is also associated with reaction time and general cognitive abilities, but as importantly is an indicator of a participant's ability to ignore irrelevant distractors (Aust & Edwards, 2016). Several studies have found UFOVSA to be particularly relevant to driving proficiency: Wood, Chaparro, Lacherez, and Hickson (2012) found that UFOVSA was the best predictor of safe driving in a closed-road driving test which looked at driving performance while having to engage with visual and auditory distractors (in this case summing two numbers viewed on a screen just out of direct visual field or presented from a speaker in the car). Their results supported the claim that UFOVSA is an effective predictor of driving competency, particularly in difficult driving conditions.

A later study by Willstrand, Broberg, and Selander (2017) examined the performance of 80 drivers all over the age of 70 years, their results on the UFOV and other tests, and how each related to on-road driving. The off-road tests included visual acuity, the full range of UFOV tests (UFOVPS, UFOVDA, UFOVSA), and Trail Making Test (Reimers, 2019; Reitan, 1955; a two-part neuropsychological test of attention, processing speed and overall cognitive functioning). Participants then completed a 20 kilometre on-road driving assessment of moderate complexity that included right and left turn intersections, roundabouts, traffic lights, and road signs. Among their findings was the number of on-road driving errors increased with the age of the driver, and importantly, performance on the UFOVSA task significantly correlated with on-road attention errors. These errors, observed and rated by a driver-trained occupational therapist during the on-road assessment, included failure to attend to the right, left, or straight ahead, and failure to attend to rear-view mirror, signs, road marks, and traffic lights. The authors maintained that the relationship between an increase in driver errors and poorer performance on the UFOVSA supported the usefulness of UFOVSA for detecting deficits in driving-related attention skills in older drivers (Willstrand et al., 2017). Other examples where UFOVSA has singularly been useful in identifying driving-related attention deficits include UFOVSA as a predictor of the propensity for a driver to be distracted by a secondary task (mobile telephone conversation, text messaging, and emailing) in a sample of 50 commercial drivers who participated in a simulator driving test (McManus, Heaton, Vance, & Stavrinos, 2016), and UFOVSA has also been reported as having very good specificity (88.9%) when used to predict the likelihood of passing an on-road assessment in post-stroke patients (George & Crotty, 2010).

Training for Improvement on Useful Field of View – Selective Attention

Given the strong relationship between UFOVSA and driving proficiency, the question arises as to whether training that improves performance on UFOVSA, may also transfer to improvements in on-road driving performance. Studies exploring the trainability of the UFOVSA and the other UFOV tasks suggest that the developers of the UFOV Test are interested in the possibility of using such training to address the impairment in driving and other activities of everyday living for older adults. The ACTIVE study (Ball et al., 2002; Jobe et al., 2001) led to the development of a speed-of-processing training (SOPT) protocol that has been trialled on a number of groups to improve UFOV performance (Ball & Owsley, 2000; Roenker et al., 2003). The SOPT protocol is a modified version of the UFOV test itself. Specifically, this process involved breaking down each UFOV task into separate training elements, then reducing the complexity and difficulty to suit the starting ability of the participant. Once the participant had mastered that level, the difficulty and/or complexity increased in stages, which the participant then practiced until they reached proficiency in the whole UFOV test, step by step. Examples of modifications to the UFOV tasks to build the SOPT regime include increasing display duration, decreasing the distance from the peripheral target from fixation, making the peripheral target a different colour from distractors, and/or the manipulating the luminance of distractors.

Following from the ACTIVE study, Roenker et al. (2003) found that SOPT improved UFOV performance, and importantly, improved the driving skills of at-risk drivers. Of considerable note is that compared to the driving simulator group, the SOPT high-risk driving situations, such as at busy intersections, during the post training on-road drive. In contrast, the driving simulator group only improved on mechanical actions, such as signalling and lane position. It is important to highlight these results, specifically regarding the improvement of on-road driving performance for the group of at-risk drivers who only did the SOPT. This result demonstrates the far-transfer of these training gains firstly to the UFOV test itself, but then also to actual on-road driving, as indicated by fewer manoeuvring errors which demonstrates

Wolinsky, Van Der Weg, Howren, Jones, and Dotson (2016) also found that SOPT significantly improved UFOV performance for their intervention groups (Group 1 – 10 hrs SOPT training in lab; Group 2 – 10 hrs SOPT training plus 4 hrs booster sessions in lab; Group 3 – 10 hrs SOPT training at home; Control Group 4 – 10 hrs on-line crossword puzzles in lab). The authors did not test their groups' performance with driving but rather on a composite neuropsychological battery that included Trail-making A and B (processing speed, executive function), Symbol Digit

Modalities Test (divided attention, processing speed), Stroop Colour and Word (cognitive flexibility, processing speed executive functioning), Controlled Oral Word Association (verbal fluency), Digit Vigilance Test (sustained attention and visuomotor speed), and the UFOV Test. Unexpectedly, at the end of the intervention period and at 12 month follow-up, the authors found that after SOPT training there was a significant improvement in the composite score of the test battery for their three intervention groups, but there was also a similar and significant improvement for their active control group, resulting in little difference between their intervention and control groups. The authors attributed this outcome to possibilities that included insufficient treatment doses of the SOPT, ceiling effects for their experimental group, or that the neuropsychological tests were too heavily weighed by processing speed tests. They also questioned the appropriateness of a crossword puzzle game for use as an attention-control task.

Targeted Selective Attention Cognitive Training

The SOPT described above involves complex lab-based activities which means they would not be accessible to other older adults except through participation in formal experiments. Thus, a question of interest is whether a suite of training tasks could be developed, with each task targeting attentional functions, but could also be more accessible to those who may benefit from attention-specific training. Such an intervention could be accessible in a user’s home at a time convenient to them. More importantly, such an easily accessible training program would allow the exploration of the possibility that training attention directly could transfer training gains to improvement in the UFOVSA task. Then, by logical extension, this could potentially improve driving performance, as was demonstrated in the ACTIVE study discussed above. Notwithstanding, the aim of the current study was to take the first step and determine whether a set of ‘simple’ cognitive tasks, that is easily accessible from a familiar environment, can increase UFOVSA performance.

To explore these questions, three testing sessions were carried out in the laboratory (Time1, Time2, Time3, each two weeks apart) where participants completed controlled testing on UFOVSA. During the period between Time2 and Time3, participants completed 14 daily home-based training sessions on their own computer. It was hypothesised that there would be no change in performance in UFOVSA between Time1 and Time2 (control period) when no training activity was undertaken by participants. However, at the end of the control period, those participants who completed the 14 consecutive days training on their home computer between Time2 and Time3 (training period) would demonstrate transference of training benefits to UFOVSA at Time3 in the laboratory. Moreover, those participants, whose 14 consecutive training sessions were of specific attention training tasks, would show greater transference of training gains than those who completed 14 days of alternative training on tasks targeting working memory rather than attention.

Method

Detailed information about participants, data collection and analysis is available in the Methods Chapter.

Results

All data were analysed using the Statistical Package for the Social Sciences (SPSS: Version 22) with an alpha of .05. All comparisons were planned. As discussed in the Methods Chapter, two data sets were combined and analysed for this study. The two data sets comprised of the first group of 26 participants who completed the 14-day no-activity control period between Time1 and Time2, then the 14-day training period, followed by Time3 (WithControl). The other data set was from participants who only completed the intervention; that being Time2, intervention, then Time3 (NoControl – 24 participants). This resulted in total data for 50 participants for the intervention, plus no-activity control data for 26 of those 50 participants. As the data was collected across two different designs, an independent-samples t-test was done to compare all test scores at the first testing session. As indicated in Table 3.4 (Methods Chapter), the only significant difference between groups was the number of years driving - the WithControl group (M = 56.46, SD = 7.91) had significantly more years driving than the NoControl group (M = 50.71, SD = 8.90, p = .02). Although significant, this difference is unlikely to be important as both groups had over 50 years driving and would be considered well-experienced drivers. Otherwise, there were no other significant differences in scores between the two groups.

A further advantage of combining the two data sets was that those in the WithControl group had done the UFOVSA twice (Time1 and Time2) before beginning the training period whereas those in the NoControl group, who only did the training period, did the UFOVSA only once (Time2) prior to commencing training. This allowed the opportunity to explore the possible impacts of practice effects over and above the training per se. Although there has been little targeted examination of practice effects related to repeated testing with UFOV, a study of recovering stroke patients who repeated the UFOV monthly, concluded that their improvements in UFOV scores were directly related to improving abilities rather than practice effects (McNamara et al., 2018). (Bentley et al., 2012) found that weekly UFOV testing resulted in a significant improvement between week one and week two performance in their younger sample, but not in their older control group. Thereafter, there was no further improvement following repeated testing. Therefore, the documented evidence thus far suggests that there would be little likelihood of a practice effect over two sessions, however this will be explored further. Moreover, in regard to the between-subjects effect, random allocation to the Attention or the Working Memory training group ensured that any benefit that may have arisen from extra exposure to the UFOVSA task was shared across both interventions (see Figure 5.1).

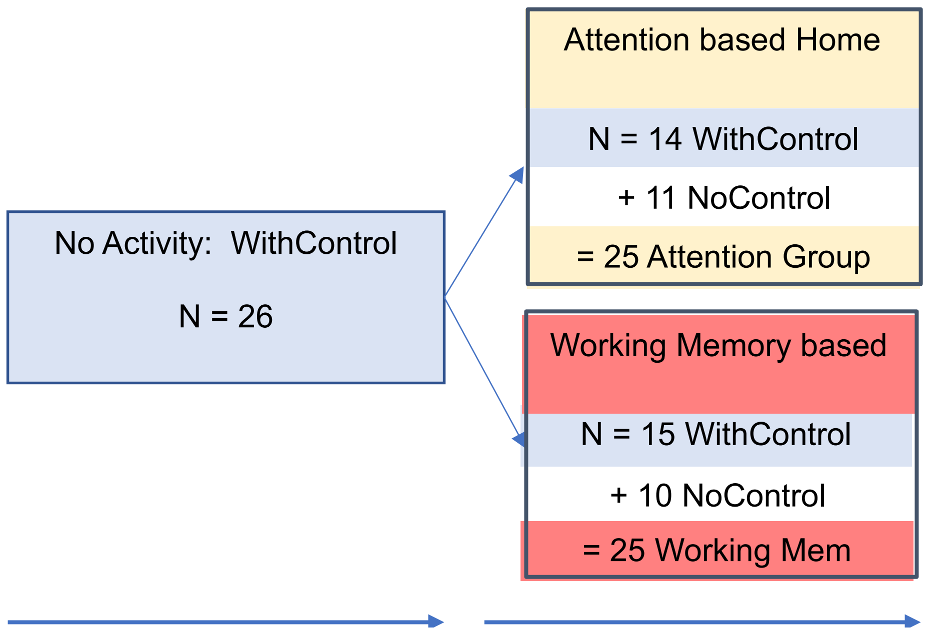

Figure 5.1. Timeline of activities completed by participants in each experimental group. WithControl group completed all three laboratory-based sessions as well as the 14-day home-based training. NoControl group commenced their participation at Time2, completed the 14-day home-based training and Time3. Therefore, a total of 50 participants completed the home-based training and included 26 participants who contributed to the control dataset.

To explore potential practice effects in our participants' results, a comparison was done for all laboratory tasks (UFOVSA and Conjunction Search) completed directly before the 14-day training; this is Time2 for the WithControl group, and Time1 for the NoControl group (i.e., any practice effect would be most likely to happen for the WithControl group who had already done the UFOV once). As indicated in Table 5.1 and Figure 5.2, there was a significant difference in scores for the UFOVSA task between the WithControl group (M = 186.82, SD = 75.05) and the NoControl group (M = 254.33, SD = 115.22; p = .02; Mean difference = 67.51, SE = 29.37), where the WithControl group was significantly faster than the NoControl group. This difference is likely due to the WithControl group having practiced the UFOVSA task once before. Of importance is that this advantage arose prior to the intervention, meaning that random allocation to each of the two intervention conditions ensured both groups had close to equal share of the advantage. Secondly, being an improvement in UFOVSA performance means that overall training-related gains from the intervention need to be greater to reach significance. Although the benefit was shared between the two experimental groups, the impact of this practice effect will be addressed more fully in the discussion.

Table 5.1. Independent t-test Results Between Participants with a Control Period and Those without a Control Period (for the lab-based tasks only) at Time2, prior to Commencement of Cognitive Training (First Time for NoControl and Second Time for WithControl). This was to determine differences between 'training' and 'no training' groups at the start of Time2, to determine if there is a pre-existing difference between the two groups before the intervention. This is illustrated in 'A' in Figure 5.2.

	Time2 Mean (SD)		
	With Control (n = 26)	No Control (n = 24)	
UFOVSA (ms)	186.82 (75.05)	254.33 (115.42)	$t(47) = 2.48$, $p = .02$*
CSRT (ms)	1554.31 (345.65)	1567.64 (332.77)	$t(47) = 0.14$, $p = .89$
CSA/c (%)	94.15 (4.43)	94.78 (2.32)	$t(47) = 0.47$, $p = .56$

Note: UFOVSA = Useful Field of View Task 3 – Selective Attention; CSRT = conjunction search reaction time; CSA/c = conjunction search accuracy.
* $p < .05$

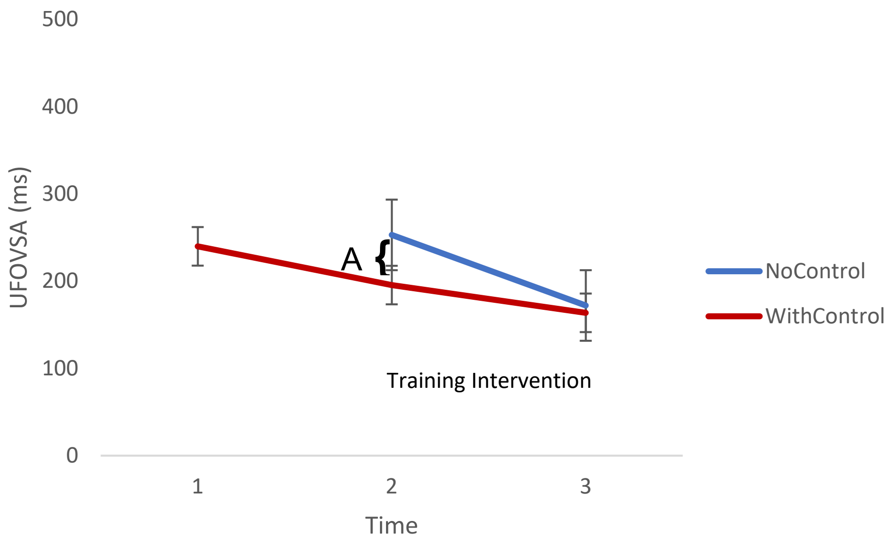

Figure 5.2. Comparison of UFOVSA scores for participants who completed a Time1 to Time2 'no activity' control period (WithControl) vs. those who did not (NoControl). Results indicating a borderline significant difference between the UFOVSA scores for the WithControl group and the NoControl group at commencement of the training intervention as indicated by 'A'.

As described in the Methods Chapter, participants were alternately assigned to either the attention-task training (Att) or the working memory-task (WM) conditions, resulting in 25 participants in each group. A comparison of baseline assessments across the two groups indicated the significant difference in Montreal Cognitive Assessment (MoCA) scores with the Attention group scoring significantly lower than the Working Memory group. This difference will be considered as part of the review of results. Refer to Table 5.2 for a summary of demographics, Raven's Standard Progressive Matrices (RSPM) and MoCA results.

Table 5.2. Summary of participants' demographic information across training conditions

	Total Participants (n = 50) n(%) or mean(SD)	Att Training (n = 25) n(%) or mean(SD)	WM Training (n = 25) n(%) or mean(SD)		
Age	73.6 (7.3)	74.0 (7.1)	73.2 (7.7)	$t(48) = 0.39$	$p = .70$[a]
Sex					
Male	26 (52)	14 (54)	12 (46)		
Female	24 (48)	11 (46)	13 (54)	$\chi^2(2, N = 50)$	$p = .78$[b]
Education	16.0 (3.2)	15.8 (3.1)	16.1 (3.3)	$t(48) = -0.31$	$p = .76$[a]
MoCA	28 (1.6)	27.1 (1.7)	28.2 (1.2)	$t(48) = -2.7$	$p = .01$*
RSPM	50 (7.7)	49.1 (7.5)	49.9 (8.1)	$t(48) = -0.4$	$p = .73$[a]

* significant at .05
[a]Independent samples *t*-test.
[b]Pearson Chi-Square with Continuity Correction
Att Training = training on attention tasks; WM Training = training on working memory tasks; MoCA = Montreal Cognitive Assessment; RSPM = Raven's Standard Progressive Matrices.

As with the UFOVDA study, multilevel linear modelling (MLM) was used for analysis (refer to the Methods Chapter for more information on this method). An intraclass correlation coefficient was calculated using a single rating, absolute agreement, 2-way mixed-effects model (CCI = .52, $F(2,48) = 12.71$ $p < .001$, 95% CI [.24: .74]) between Time1, Time2 and Time3. Given there were fewer data points at Time1 due to the combined design, a second CCI was calculated using only Time2 and Time3 data (CCI = .52, $F(1,48) = 11.80$, $p = .001$, 95% CI [.24:.71]). These results are very similar so the inclusion of Time1 did not change the outcome. Therefore, a two-level hierarchical model was used to assess the effects of training type (Att or WM training) on the UFOVSA scores over time. First level units were condition (Att or WM scores in ms) and second level units were the 50 participants.

A random intercept model was found to be significantly better than the fixed effects model $\chi^2(1) = 35.1$, $p < 0.01$. However, including a random slope with the random intercept did not significantly improve the model so the random intercept-only model was retained for further analysis.

As predicted, there was a significant main effect of Time ($F(2,73.36) = 18.42$, $p < .001$) across the three testing sessions. However, there was neither significant main effect of Condition ($F(1,48.97) = .495$, $p = .49$) nor a significant interaction between Condition and Time ($F(2,73.36) = 1.35$, $p = .27$). Planned comparisons indicated a significant difference in UFOVSA performance between Time1 and Time2; Mean difference = 44.29 [SE 15.26], $t(73.63) = 2.05$, $p = .04$, 95% CI [13.88, 74.69]. Given that Time1 to Time2 was only completed by the WithControl group, these results suggest improvement during the Control period despite there being no intervention (as may have been predicted by the significant difference between WithControl and NoControl groups prior to allocation to intervention groups). There was also an improvement in performance between Time2 and Time3 for all participants after the training intervention was completed but it was not significant; Mean difference = 49.08[12.90], $t(70.23) = -1.67$, $p = .10$, 95% CI [23.35, 74.80]).

In view of there being no significant difference between Conditions, the model was re-run without Condition as a variable to increase power in the analysis. Again, there was a significant effect of Time ($F(2,75.63) = 17.53$, $p < .001$) across the three testing sessions. Also, as expected, there was still a significant difference between Time1 and Time2; Mean difference = 43.74 (SE 15.38), $t(76.31) = 2.84$, $p = .006$, 95% CI [74.37, 13.11] but there was now also a significant difference between

Time2 and Time3; Mean difference = 47.94 (SE 13.00), $t(73.34) = -3.69$, $p > .001$, 95% CI [73.85, 22.04]. However, as there was only a 4.2 ms difference between Time1 to Time2 and Time2 to Time3, it was assumed this did not represent a significant difference in magnitude between the two differences. In other words, the increased performance between Time1 and Time2 was sufficiently similar to that between Time2 and Time3 (intervention) to suggest that there was no improvement beyond an overall practice effect (refer Figure 5.3).

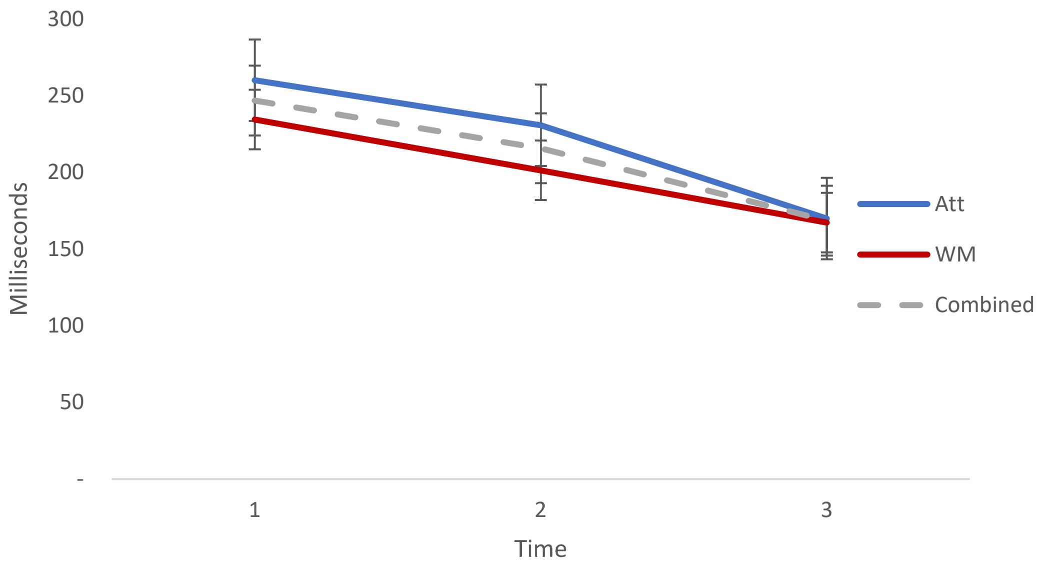

Figure 5.3. Indication of the different interventions – Att = Attention group and WM = Working Memory group, plus the outcome of combining the two intervention groups

Finally, after further inspection of the data (refer to Figure 5.4*)*, two participants' data were removed on the basis that their performance had deteriorated over the three testing sessions. This was contrary to all other participants who had improved (overall between Time1 and Time3). Deletion of these data points resulted in a new Mean difference between Time1 and Time2 of 40.89 ms, (SE = 14.55) 95% CI [12.11, 69.67] and between Time2 and Time3 of 58.38 ms (*SE* = 12.15), 95% CI [34.17, 82.58]. Although these differences equate to a 40.89 ms change in the difference between Time1 and Time2 and a 58.38 ms change in the difference between Time2 and Time3, it remains that removing these data points did not change the results in any substantial way.

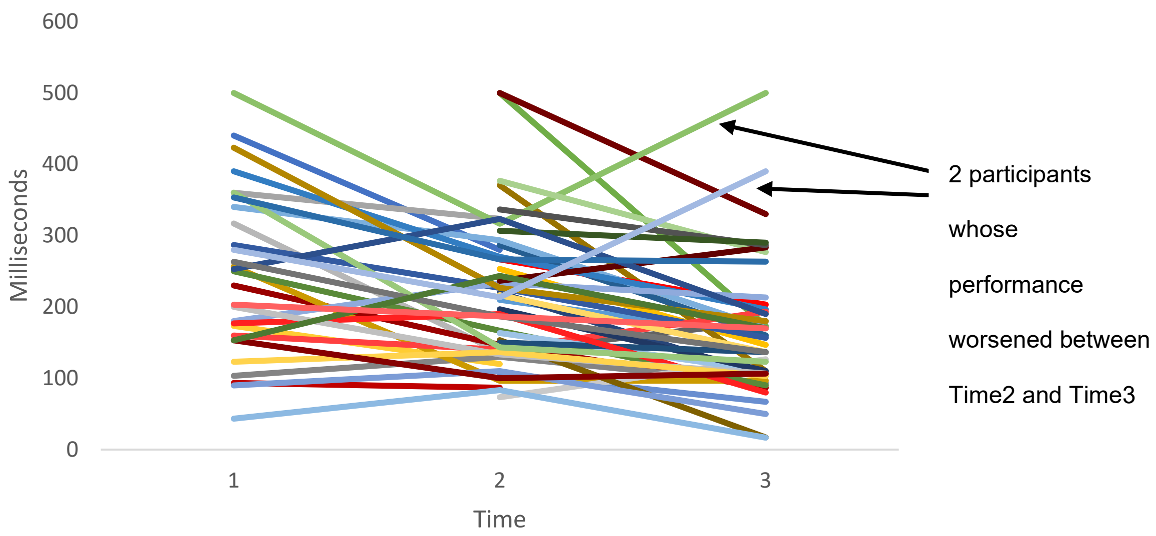

Figure 5.4. Visual representation of individual performance on UFOVSA indicating two participants whose performance deteriorated between Time2 and Time3 which were deleted, and the remaining data analysed separately.

Discussion

The main aim of this study was to assess the possibility of the transfer of training gains, as a result of 14-days training on several easily accessible, internet-based cognitive tasks, to the UFOVSA task – a task demonstrated to predict driving proficiency in older adults. It was expected that training on specific attention-based tasks would result in greater improvement (and thus transfer) compared with training on other, non-attention targeted tasks.

Results indicated a significant main effect of Time across the three testing sessions. However, there was no significant main effect of Condition, nor a significant interaction between Condition and Time indicating there was no benefit of the attention-based training over working memory training during the 14-day home training period. Of particular note was that planned comparisons indicated a significant difference in UFOVSA performance between Time1 and Time2; however, although there was an improvement in performance between Time2 and Time3 for all participants after training, it was not significant. These results indicate a clear practice effect between Time1 and Time2, but the expected improvement in UFOVSA performance due to the training intervention did not occur. This suggests that all improvements in UFOVSA performance might have been due to practice effects. This outcome is contrary to the results of a reliability and validity investigation by the authors of the UFOV Test version for PC (used in this study) that reported a test-retest reliability coefficient of 0.85 in the UFOVSA task, which, it was suggested, provided for stable performance over time (Edwards et al., 2005).

This unexpected outcome prompted a further review of the literature, which revealed a similar practice effect had been previously described by Bentley et al. (2012) when comparing performance on the full UFOV test between glaucoma patients and healthy controls. The authors included several smaller groups, alongside their main experimental groups, to look at test-retest and repeatability effects. Four groups in all included two young adult groups (Repeatability group, n = 17, mean age = 33 yrs; test-retest group, n = 13, mean age = 28 yrs), an older group (n = 21, mean age = 66 yrs), and an older group with glaucoma (n = 22, mean age = 68 yrs). Specifically, the younger Repeatability group was administered the UFOVSA five times on the same day. This younger group had a small but not significant improvement between test times 1 and 2 but thereafter, there was no further improvements in performance over the next three testing times, indicating no further practice effects beyond the first two exposures to UFOVSA. However, the young test-retest group and the older control participants did the test at time 1 and then repeated the test at an interval of around 14 days. The younger group had a significant improvement between the two testing times and the older control group (those without glaucoma) also improved between Time1 and Time2, but the magnitude of improvement did not reach significance. These groups did not do a third test so there is no indication if the pattern of performance of the younger Repeatability group would have been replicated such that the practice effect disappeared after the second exposure. Burns, Kremer, and Baldock (2005) also found a similar practice effect when they compared UFOVSA with other tests used to assess older adults' driving capabilities. Their participants completed the UFOVSA tasks twice, one week apart, but again, although they found clear practice effects after the second testing session, they did not test again and so did not explore practice effects beyond test-retest.

One explanation for the practice effect between Time1 to Time2 is the sheer difficulty of the UFOVSA task: Throughout testing in the current study, anecdotal comments from participants were recorded and a common remark after first completing the UFOVSA task related to the difficulty of the task, which, in fact, took participants by surprise. Comments such as "I didn't see anything" and "That was awful" supported this reasoning. Later, comments from participants during the second lab session and prior to the UFOVSA task, frequently related to how much harder the UFOVSA task was, compared to the other lab-based tasks. These participant comments support the idea that first-go at UFOVSA was very surprising, however, thereafter the participant then knew what was coming and could settle into task performance that better reflected their ability. For the current study, in addition to the test-retest effect between Time1 and Time2, there was a non-significant improvement between Time2 and Time3, but this change cannot be attributed to any intervention effects due to 42% of the data being that of the NoControl group who were likely experiencing that same test-retest effect previously experienced by those in the WithControl group.

To investigate this further, another analysis was done which only included the WithControl group who had done all three UFOVSA tests (n = 26) (refer to Figure 5.5 for a visual representation of the pattern of results for this group). Results indicate that without the NoControl group data, there was again a significant main effect of Time, $F(2,52.12) = 14.58$, $p < .001$, however planned comparisons confirmed the significant practice effect between Time1 and Time2, $t(51.64) = 3.66$, $p = .04$, but there was no significant improvement between Time2 and Time3, $t(52.38) = 1.76$, $p = .08$, supporting the suggestion that it was the data of those new to UFOVSA that contributed to the improvement observed when all participants' data were included. Notwithstanding, the effect was trending toward significance suggesting a larger group may have resulted in the expected transfer of training gains to the UFOVSA task. Although the participant numbers in this study were similar to the control groups in the study by Bentley et al. (2012), a larger sample of participants who completed the no-intervention period as well as the 14-day intervention may well have provided better evidence of training effects on UFOVSA performance. In addition, providing more practice at the UFOVSA task, specifically a pre-study practice of the task, may have eliminated the test-retest effect found here, and identified by Bentley et al. (2012).

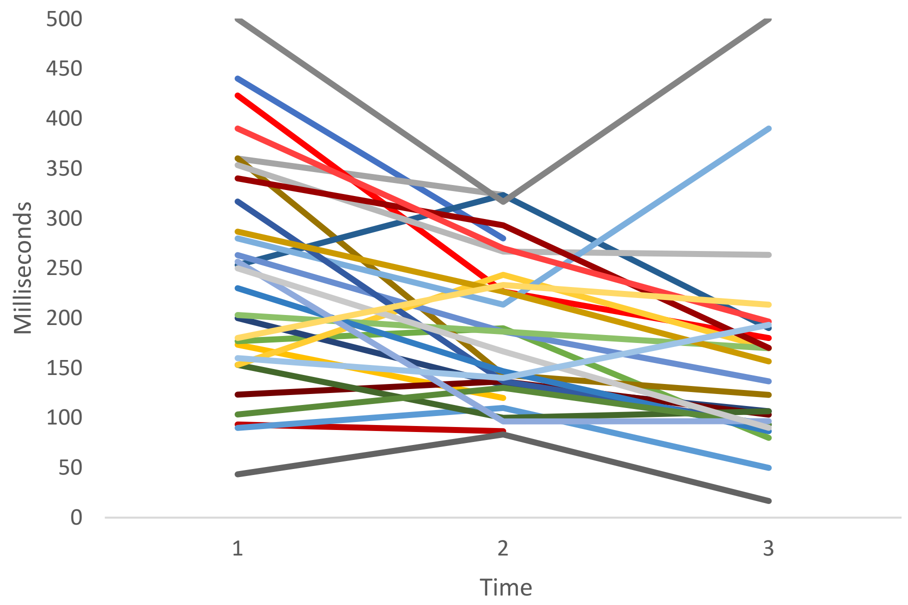

Figure 5.5. Visual representation of performance across Time1 to Time2 to Time3 for all participants in the WithControl group (excluding the NoControl results) indicating trends of ongoing improvement in performance (apart from the two participants whose performance worsened between Time2 and Time3.

Therefore, based on the outcome of this study, the practice effect interfered with any possible training gains that may have arisen from the intervention and thus no conclusion regarding the independent training and its effect on UFOVSA performance can be made.

However, it is nevertheless prudent to consider the components of the intervention and whether they were appropriate as training tasks for UFOVSA. Unlike divided attention which facilitates attending to more than one task at a time, selective attention is about enabling the honing-in on relevant information while preventing the capture of attention by task-irrelevant distractions. In UFOVSA, the objective is to identify the location of a target in the visual periphery and decipher a two-alternative puzzle in the direct field of view, while ignoring a high number of distractors. The distractors in UFOVSA are similar in size, colour, and luminance to the two targets and are only differentiated by shape, however those distractors are also distributed across the entire visual field, influencing both the central and the peripheral targets (refer to Figure 5.6). Further, the UFOVSA presentation time is too fast to allow any eye movements, so peripheral vision and covert attention are both engaged to successfully complete the task.

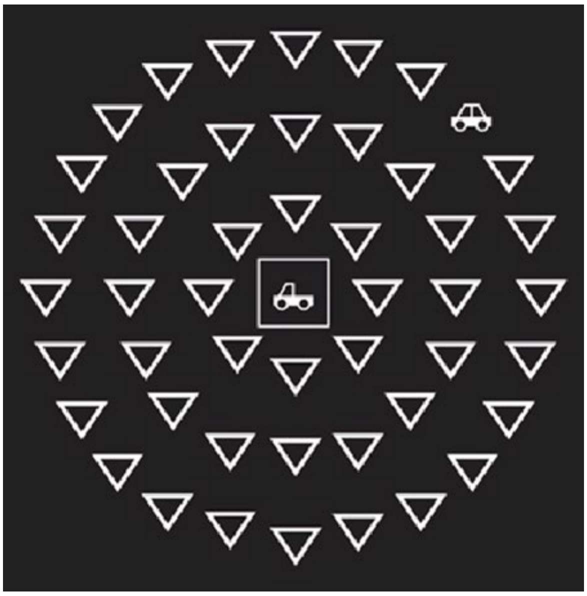

Figure 5.6. UFOVSA screenshot indicating central decision task; “car” or “truck” and one of eight possible locations of the peripheral location task along with distractors.

It may be that the tasks included in the training regime in this study did not provide the appropriate skill training that would then transfer to improved performance in the UFOVSA task. The three training tasks in the Attention condition were a conjunction search task, a speeded visual search task, and a conditional continuous performance task, each of which is described in detail in the Methods Chapter. The conjunction search was selected as a correlate of selective attention because of the requirement to filter out distractors in order to focus on the target. Nevertheless, unlike the UFOVSA task, the conjunction search task used for training was self-paced, allowing eye movements and shifts in attention. The UFOVSA conversely depends on covert attention because of the brief presentation time. Therefore, there may be some distinction between the use of overt and covert attention that impeded the transfer of training from the conjunction search to UFOVSA. Related to this, the conjunction search training task requires the overt shifts in attention to bring the fovea in alignment with the next visited target for the visual system to retain or reject as a target. However, the fast presentation of the UOFOVSA task and inability to deploy overt attention means that attentional selection of the second target in the periphery is confounded by the close proximity of the distractors. Such that the centre-surround visual field of peripheral neurons is now so large as to encompass both target and surrounding distractors (Anton-Erxleben & Carrasco, 2013; Veríssimo, Hölsken, & Olivers, 2021). Therefore, the two tasks may be drawing on two very different attentional mechanisms and be dependent on two very different physical limitations of the visual system.

The speeded visual search task (Gabor task) used in the training accommodated some of the differences presented by the conjunction search training task, by limited time presentation, similar to that in the UFOVSA. However, in this case there was no simultaneous central task, and the distractors were further apart compared to UFOVSA. Once again, these differences may have drawn on different visuo-spatial mechanisms.

The final training task in the Attention condition was conditional continuous performance and it very much targeted selective attention in order to ignore the potent but irrelevant distractors, but each letter was presented serially and at fixation and so did not require the broadening of the spotlight of attention to identify the target. Therefore, on reflection it is possible that, despite the intention to provide training in a variety of easily identified and accessible attention tasks to enable transfer of attention in general, the more complex visual requirements of UFOVSA were not met by the training regime.

Of interest, there is some dispute as to whether UFOVSA is targeting selective attention or some other attentional function. Burns et al. (2005) described UFOVSA as creating visual crowding, rather than engaging selective attention per se, where visual crowding results in a reduction in the ability to recognise objects when there are distracting flankers (Levi, 2008). The authors developed a task that presented a target between flanking distractors (located either each side, or above and below the target) at varying angles away from fixation that resulted in a crowding effect around each target. The authors named this effect Crowding Across the Visual Field (CAVF). When they identified task decrements in CAVF performance for a group of older adults compared to a younger group, the authors noted that these results were strongly correlated with the results from each group's UFOVSA performance, thus suggesting that UFOVSA could be acting as a proxy for visual crowding rather than directly tapping selective attention, which is feasible given the busyness of the screen with the distractors present. It has also been argued that the inability to disengage attention from a target, rather than being able to ignore distractors while focusing on a target, may underlie UFOVSA: Cosman, Lees, Lee, Rizzo, and Vecera (2012a) identified that participants with poorer UFOVSA performance demonstrated normal selective attention functioning across varying eccentricities on a flanker task, in fact, performing as well as the group whose UFOVSA performance was within the normal range. However, the UFOVSA impaired group were much slower than the unimpaired group in responding to an invalid cue on a cueing task, suggesting the impaired group were having difficulty disengaging from the cued space, and thus had an impairment in disengaging attention. As such, the authors proposed that the inability to disengage attention from a cued position, rather than an impairment in selective attention, was what compromised performance on the UFOVSA task. Despite the ambiguity in identifying which cognitive function is responsible for UFOSA performance, it remains that this task has a high predictability of future crash risk and is a good indicator of driving proficiency for older adults (K. J. Anstey & Wood, 2011; Wood et al., 2012).

Future research, with the aim of investigating and eliminating the pronounced practice effect found in the current study, may better answer the question of whether home-based cognitive training on easy-to-access, computer-based tasks can produce training gains that transfer to improved performance on the UFOVSA task. Repeating the experiment in full (including the 14-day control period) but allowing each participant to practice the UFOVSA task until familiarity fully eliminates the practice effect, prior to commencing the intervention, is likely to provide a clearer result. Replicating the repeatability methods applied by Bentley and colleagues (2012) by varying practice duration and intervals between practice could be investigated by having subgroups complete UFOVSA a number of times in one day, or alternatively, repeating the UFOVSA at 14-day intervals until no further performance improvement is recorded – then have each group complete the intervention as per this study. The results would be free of any practice effects and able to be examined in terms of the intervention outcome.

Conclusion

Transference of training effects was the major target of this study, however practice effects that emerged due to the difficulty and surprise factors of the UFOVSA target task overwhelmed any training gains that may have emerged. There was also an expectation that those who trained on the attention tasks would perform better on the UFOVSA task after training than those trained on working memory tasks. A difference did emerge, but it was not sufficient to reach statistical significance.

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Chapter 6: Predictors of Useful Field of View Performance

Many older adults consider that maintaining their licence to drive is a key element of independence, which has been identified is a critical component of successful ageing and protective against some adverse health outcomes (Al-Hassani & Alotaibi, 2014; Byles, Leigh, Vo, Forder, & Curryer, 2015; Chihuri et al., 2016). However, for Australian drivers 65 years and older, road crashes resulting in death or severe injury continue to rise (Bureau of Infrastructure Transport Research Economics, 2016, 2022). Further, older adults who have ceased driving are reported to have lower quality of life, less engagement in social activities, and are more isolated than their driving counterparts (Byles et al., 2015; Gardezi et al., 2006; Liddle, Gustafsson, Bartlett, & McKenna, 2012). Therefore, it is important to identify effective means of assessing driving capability and predicting crash risk for older drivers in environments that do not involve driving in order to target those who may benefit from additional driver training, or who are too great a risk to maintain their licence to drive.

Consequently, there has been much interest in assessing the effectiveness of tests that predict driving outcomes for older adults (K. J. Anstey et al., 2005; Cizman Staba, Klun, Stojmenova, Jakus, & Sodnik, 2022; Eramudugolla et al., 2022; Wood, Anstey, Kerr, Lacherez, & Lord, 2008). In their meta-analysis, Mathias and Lucas (2009) found that, among a range of common cognitive tests used for driving assessment and screening, the Useful Field of View (UFOV) test was one that stood out as a good predictor of on-road driving, simulator driving performance, and driving problems. Since then, the UFOV has remained a common research tool used in the assessment of driving risk in older drivers (Dickerson, 2014). The UFOV has three subtests that each build on the previous task and increase in difficulty. The first subtest is assessing Processing Speed (UFOVPS). In this task the observer must identify if the object presented at fixation is a car or a truck. The second subtest is Divided Attention (UFOVDA) where, in addition to the object identification task of UFOVPS, the observer must simultaneously identity the location of a second object (always a car) in one of eight peripheral radial positions. Lastly, the Selective Attention subtest (UFOVSA) is the same as UFOVDA, but the array includes 47 triangles of the same size, colour and luminance as the targets, that the observer must ignore in order to locate the peripheral target and simultaneously the identity of the car/truck at fixation. Each of these subtests is described in detail in the Methods Chapter.

In their analysis, Mathias and Lucas (2009) demonstrated that except for UFOVPS, the other two UFOV subtests and the UFOV total score were found to produce an effect size large enough to identify significant differences between older drivers at high or low risk of previous or future on-road crashes (Cohen's $d < 0.8$). Of interest was that they identified that the cognitive performance differences between those who pass or fail driving assessments become greater as people age. This observed phenomenon may in fact reflect interindividual variability which is the increased diversity in response performance across participants that occurs with increasing age. Such variability has been attributed to individual differences including pre-symptomatic cognitive pathology which may account for those identified as poorer cognitive performers (Hedden & Gabrieli, 2004; Wilson et al., 2002) or to levels of preserved cognitive functioning as suggested by the concept of cognitive reserve, brain reserve, and brain maintenance (Balzarotti, Biassoni, Confalonieri, Meinero, & Ciceri, 2021; Barulli & Stern, 2013; Nyberg, Lövdén, Riklund, Lindenberger, & Bäckman, 2012) which may also account for high cognitive performers.

Although UFOV test has been consistently successful in assessing and predicting driving capability, it has been somewhat unclear as to which cognitive and perceptual components tapped by the UFOV test underlie changes in performance. The authors of UFOV originally purported that performance variability was due to differences in the size of the useful field of view (Ball, Beard, Roenker, Miller, & Griggs, 1988), that being the area where, in a brief glance, visual information can be gleaned from the environment without head or eye movements (Sanders, 1970). It was held that normal variations in the useful field of view are due to target/distractor similarity, exposure time, and the difficulty of any concurrent central task. It was also maintained that the useful field of view becomes smaller in older adults, as indicated by more frequent errors and slower response times when compared with younger adults' performance (Ball et al., 1988; Owsley, 2013). Later, with the development of the PC-based version, the UFOV test was described as measuring age-related changes in speed of processing, the ability to divide attention and to ignore irrelevant information (Edwards et al., 2005). Since then, numerous studies have debated the validity of these discussions around the size of the useful field of view, processing speed, divided attention, and selective attention. For example, Matas et al. (2014) concluded that UFOVPS related to more basic visual functions of visual acuity and contrast sensitivity. Specifically, they suggested that UFOVDA was accessing change detection, processing speed and general cognitive ability, and UFOVSA was accessing visual crowding, processing speed and contrast sensitivity. Another study exploring the neural correlates of the UFOV test supported the finding that UFOVPS engaged early perceptual selection and top-down attentional control

(O′Brien, Lister, Peronto, & Edwards, 2015) and also found that processing speed featured across all UFOV subtests. However, it was noted that the ERP components usually associated with attention processes (N1, P2 and N2pc) did not correlate with performance on any of the UFOV subtests. Further, an earlier study found that working memory, spatial competence and a conglomerate of speeded executive tasks correlated with performance on the UFOVDA in a group of older adults (K. J. Anstey, Horswill, Wood, & Hatherly, 2012), again suggesting that the cognitive and perceptual constructs of UFOV performance are quite varied.

Moreover, it may be that there are other determinants of UFOV performance beside perceptual factors, such as emotional or volitional processes. For example, it has been noted that older adults may use more conservative decision criteria that result in a time-accuracy trade-off in timed choice paradigms (Forstmann et al., 2011; Rabbitt, 1979; Ratcliff, Thapar, & McKoon, 2007). This strategy may account for the slower response time to maintain a 75% accuracy rate in each of the UFOV subtests. Confidence and attitude may also influence UFOV performance as these constructs have also been linked to on-road driving performance, crashes and traffic violations in an older population (Adrian, Postal, Moessinger, Rascle, & Charles, 2011; Lucidi, Mallia, Lazuras, & Violani, 2014; Parker, Macdonald, Sutcliffe, & Rabbitt, 2001; Schwebel et al., 2007).

Therefore, the aim of this study was to explore the relationship between the individual UFOV subtests and a number of potential predictors of performance, in order to examine what it is that makes the UFOV test a good predictor of driving ability. In particular, the relationship between driver attitude and confidence, and UFOV performance was of interest as older drivers often self-regulate or cease driving altogether in response to driving-related stress (Feng et al., 2020; Hakamies-

Blomqvist & Wahlström, 1998), poor cognition, or loss of driving confidence (Conlon, Rahaley, & Davis, 2017), and as such, these cognitive and confidence changes may also be reflected in UFOV performance. Thus, driver attitude and confidence was measured with questionnaires made up of items from the Perceptions of Driving Skills Questionnaire (White et al., 2011), the Self-Rating Hazard Perception Questionnaire (Conlon & Herkes, 2008), and the Manchester Driving Behaviour Questionnaire (Parker et al., 2000; Reason et al., 1990). These measures identify driving behaviours that are related to driving risk, particularly optimism bias for driving skills and crash risk (White et al., 2011), self-perceptions of driving skill and ability (Conlon & Herkes, 2008), as well as self-report aberrant driving behaviours of lapses, errors and violations in older adults (Parker et al., 2000). Lapses, errors and violations have each been found to be predictive of motor vehicle crash involvement (Parker et al., 2000; Reason et al., 1990) which supported inclusion of the DBQ as a potential predictor of UFOV performance. It was expected that performance for those with more lapses, errors and lower driving confidence would be slower on the UFOV test.

Global cognitive functioning is usually included in driver assessment studies as a screening or inclusion tool to identify cognitive impairment and has traditionally been measured using the Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975) despite the MMSE having low sensitivity and poor predictive power in relation to driving related cognitive deficits (Eramudugolla et al., 2022). However, Matas and colleagues (2014) were surprised to find that the MMSE was predictive of performance on both UFOVDA and UFOVSA despite there being no evidence of cognitive decline in their sample. Also, the tendency for males in particular to self-regulate their driving behaviours only when experiencing health or cognitive difficulties (Conlon et al., 2017) suggests that global cognitive functioning may also relate to UFOV performance. The Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) is a brief cognitive assessment that is more sensitive to mild cognitive impairment, while being less susceptible to age and education confounds than the MMSE and other brief cognitive assessments (Tardif & Simard, 2011). Hollis, Duncanson, Kapust, Xi, and O'Connor (2015) found that those older participants who failed an on-road driving assessment also performed worse on both the MoCA and the MMSE, but the MoCA was a better predictor of driver performance in those with diagnosed cognitive impairment. Therefore, it was decided to use the MoCA as the cognitive function predictor of UFOV performance. The MoCA assesses orientation to time and place, attention (serial subtraction, Digit-Span-Forward and Backward, and tapping), language (verbal fluency, sentence repetition), memory (five words), delayed recall (after five minutes with optional cues), abstraction (semantic knowledge - three pairs), naming (three animals), and visuospatial/executive (five pair Trials-B, cube copy and clock test). As with Matas et al. (2014) findings, it was expected that those who performed well on the MoCA would also be faster on the UFOV test.

Despite education attainment having a significant relationship with UFOV performance (Edwards et al., 2006), intelligence per se has not been explored as a predictor of UFOV attainment. In their study, Matas and colleagues (2014) used an Inspection Time test which is a measure of processing speed that also correlates highly with IQ and other measures of cognitive decline. Their findings did not, however, find that the Inspection Time test significantly predicted UFOV performance. Despite the lack of findings, it was decided that a more comprehensive version of a visual intelligence test may tap into the complex nature of the UFOV test, particularly UFOVDA and UFOVSA. Therefore, the Raven's Standard Progressive Matrices (RSPM; Raven, 2000) was included as a measure of intelligence to predict performance of UFOV in this sample. RSPM is a non-language-based test of IQ with norms for older adults. Specifically, RSPM has been highly correlated with other tests of intelligence and is considered a reliable indicator of Spearman's General intelligence (Spearman's "g"; Snow et al., 1984). Specifically, RSPM is a visual test directly accessing problem solving and reasoning and thus is thought to be more in line with driving as a visual activity. Therefore, it was expected that those who scored higher on RSPM would perform better on the UFOV subtests.

As discussed in Chapter 3 – Methods, perceptual skills, in particular visual search and reaction time, decline with age (Plude & Doussard-Roosevelt, 1989; T. A. Salthouse, 1996)..Therefore, it was decided to include conjunction search as a potential predictor of UFOV performance, particularly UFOVSA as was expected that those with poor conjunction search results would also have poorer performance on UFOVSA.

Lastly, demographic information including age, education (years), and driving history were included as these have been demonstrated to be related to UFOV performance (K. J. Anstey et al., 2017; K. J. Anstey & Wood, 2011). Driving history included the number of accidents the driver was involved in over the last five years, the total number of years each participant has been driving, the number of kilometres each person drove in the year they would have driven the most, and then the number of kilometres per year they now drive. It was predicted that those with more reported crashes and those with less driving experience would be slower on all

UFOV tasks. It was also expected that younger drivers, and those with more years of education, would perform faster on the UFOV tasks.

All the above-mentioned measures (attitude and confidence, cognitive functioning, visual intelligence, visual search, and reaction time) were selected on the basis that they are likely to tap into discrete cognitive or perceptual components of the UFOV in a way that can be measured independently, and thus add to the understanding of what makes UFOV a good predictor of driving ability.

Method

Participants

Fifty community-dwelling adults aged 61 to 90 years (M = 73.6, SD = 7.3; 24 female and 26 male) with a current drivers' licence and regular driving habits participated as part of the larger study as described in the Methods Chapter. Formal education ranged from nine to 21 years (M = 16, SD = 3.18). Summary demographic data for participants are presented in Table 6.1 along with the results of all study variables.

Table 6.1. Descriptive Statistics for Study Variables

	M	SD	Mdn	Mde	Range
Age (years)	73.58	7.36	73.15		60.83-90.48
Education (years)	15.98	3.18	16	16	9-21
Years driving	54	8.75	54	57	37-74
Accidents [a]	0.27	0.57	0	0	0-2
Klms/yr/thn	17,377	12,219	15,000	15,000	2,000-72,000
Klms/yr/now	12,396	9,116	10,000	10,000	1,000-55,000
MoCA	27.68	1.58	28	28	24-30
RSPM	49.50	7.70	50.50	49,50,52,55[b]	32-60
CSRT (ms)	1605.69	379.83	1524.00		1012.94-3416.83
CSAC (% correct)	94.81	2.87	94.44	97.22	87.50-98.61
DBQ Total	18.56	7.71	17.5	13,24[a]	5-39
DBQ Errors	0.69	0.39	0.70	0.80	0.10-1.70
DBQ Lapses	1.34	0.52	1.33	1.67	0.17-2.67
DBQ Violations	0.45	0.37	0.29	0.29	0-1.86
Driving Skills	12.42	19.72	13	13	4-23
Hazard Perception	27.44	5.49	26.50	24	16-41
UFOVPS (ms)	27.76	22.82	16.70	16.70	16.70-119.90
UFOVDA (ms)	89.43	97.37	43.40	16.70	16.70-393.50
UFOVSA (ms)	244.17	109.80	236.70	153.20,253.30,500[b]	43.40-500.00

Abbreviations: Klms/yr/thn = Klms driven per year during peak driving time over life; Klms/yr/now = Klms driven per year now; Moca - Montreal Cognitive Assessment; RSPM - Raven's Standard Progressive Matrices; CSRT - Conjunction Search – Reaction Time; CSAC - Conjunction Search - Accuracy; DBQ - Manchester Driver Behaviour Questionnaire; UFOVPS - Useful Field of View Processing Speed; UFOVDA - Useful Field of View Divided Attention; UFOVSA - Useful Field of View Selective Attention;
[a] Accidents (incidences that resulted in damage to the vehicle, including at-fault and no-fault) in the last 5 years
[b] Multiple modes
n = 50

Procedure

This study was completed as part of a larger project, but the relevant data was collected in one single session lasting around two hours including breaks. The one exception was that the DBQ factor analysis, carried out to further examine the regression results, accessed a second data collection occasion when participants completed baseline tests a second time and thus provided another round of questionnaire answers. Demographic information was collected via questionnaire followed by a brief interview outlining experiment procedure and gathering driving history. The Manchester Driver Behaviour Questionnaire (DBQ; Reason et al., 1990), Perceptions of Driving Skills (White et al., 2011) and Self-Rated Hazard Perception Questionnaire (Conlon & Herkes, 2008) were then completed by each participant. Following completion of the questionnaires, each participant was administered the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). The computer-based tasks followed, which comprised the conjunction search and the three UFOV tasks. These tasks were counterbalanced across participants. Lastly, participants completed the Raven's Standard Progressive Matrices task (Raven, 2000).

Measures

A full description of all assessment tools and equipment is provided in the Methods Chapter. Only information relevant to this study are detailed here. Some technical details are omitted for readability purposes, but all is included in the Methods Chapter.

Driving Attitude and Confidence. These were measured using three self-report questionnaires, those being the DBQ (version as described in Parker et al., 2000), the Driving Skills Questionnaire, and the Self-Rating Hazard Perception Questionnaire. The DBQ consists of 24 items representing driving behaviours categorised into Errors, Lapses, and Violations and measures the frequency that events occur. Examples of Error questions include "*On turning left, narrowly miss a cyclist who* *has come up on the inside*" and "*Failure to notice pedestrians crossing on turning into a side road*". Lapses include questions such as "*Forget where you left your car in a car park*" and "*Realise you have no recollection of the road along which you have been travelling*". Examples of Violations questions include "*Angered by another driver's behaviour you give chase with the intention of giving him/her a piece of your mind*" and "*Drive especially close to signal the driver in front to go faster/get out to the way*". Responders indicate by way of a six-point Likert scale ranging from never (0) to nearly all the time (5). Low scores indicate fewer self-reported incidents in each category.

The Driving Skills Questionnaire has 11 items scored on a four-point Likert scale. For items relating to events that occur when driving such as "*How often do you misjudge the distance to stop to avoid colliding with another vehicle?*", the response type is Often (3) to Never (0). Response options for items related to self-perceptions such as "*What level of stress does driving in heavy traffic cause for you?*" range from Very High (3) to Very Low (0) with reverse scoring where appropriate. Lastly, for items of perceived difficulty such as "*Judging the speed of oncoming vehicles is…*" responses ranged from Extremely Difficult (3) to Not at all Difficult (0). A low overall score on the Driving Skills Questionnaire indicates a self-perception of little or no difficulty while driving, whereas a high score indicates a perception of frequent difficulty when driving (Conlon & Herkes, 2008).

The Self-Rating Hazard Perception Questionnaire is made up of six items that self-rate the participant's ability to detect various hazards compared to the ability of other drivers the same age. An example of the questions includes "*Compared to other drivers your age, how skilful are you at spotting hazards quickly?*". Responses are scored on a Likert scale ranging from Much Less (1) to Much More (7) with low scores indicating a perception of very low ability and a high score indicating a perception of a much greater ability than other drivers of the same age.

Cognitive Performance. This was measured with the MoCA (Nasreddine et al., 2005) which is a test of cognitive function frequently used to detect mild cognitive impairment and early Alzheimer's disease. For more detail on the results of this assessment refer to the Methods Chapter.

Visual Search and Reaction Time. These were measured via a conjunction search task which is also described in full in the Methods Chapter.

Useful Field of View Test (UFOV). This comprises three computer-based tasks that increase in complexity and difficulty. The UFOV data included in the analysis for this chapter relates only to each participant's first assessment on each of the UFOV Processing Speed (UFOVPS), Divided Attention (UFOVDA) and Selective Attention (UFOVSA) tasks. Again, for a full description of the UFOV tasks, refer to the Methods Chapter.

Results

Data Screening

Each UFOV subtest was considered separately. Regression assumptions were met for all variables except for UFOVPS and UFOVDA for which the data were skewed due to ceiling effects. Skewed data is common in reaction time data, particularly when the response is a limited option decision. The UFOVPS had 60% of scores at ceiling (scores of 16.7 ms, which is the fastest score able to be recorded) and UFOVDA had 26% (refer to Figure 6.1). This was supported by the scatterplot of standardised residuals, which suggested heteroscedasticity and non-linearity in both UFOVPS and UFOVDA. Further, the variance recorded for UFOVPS was

0.001 – just barely above zero, and 0.008 for UFOVDA also confirming the ceiling effect (Schweizer, Ren, & Zeller, 2019). However, perceptual cognitive processing tasks frequently suffer these skewed distributions, simply due to the nature of the task. Specifically, although the score is a continuous variable, it cannot be less than zero and there is a lag limit built into the reaction time score. For example, UFOVPS and UFOVDA both have a 500ms boundary meaning that if there is not a response within that time, the reaction time is recorded as 500ms. This means that the reaction time score is bounded by a lower limit, which is 16.7ms (the fastest score that the system is able to record) and an upper limit of 500ms. Over time as the participant's cognitive abilities adjust to the demands of the task, performance becomes automatic, particularly when the probability of making an error is low (Schweizer et al., 2019). Therefore, it was decided to continue with the data. Increasing the data set size would still result in a similar proportion of scores contributing to the ceiling effect.

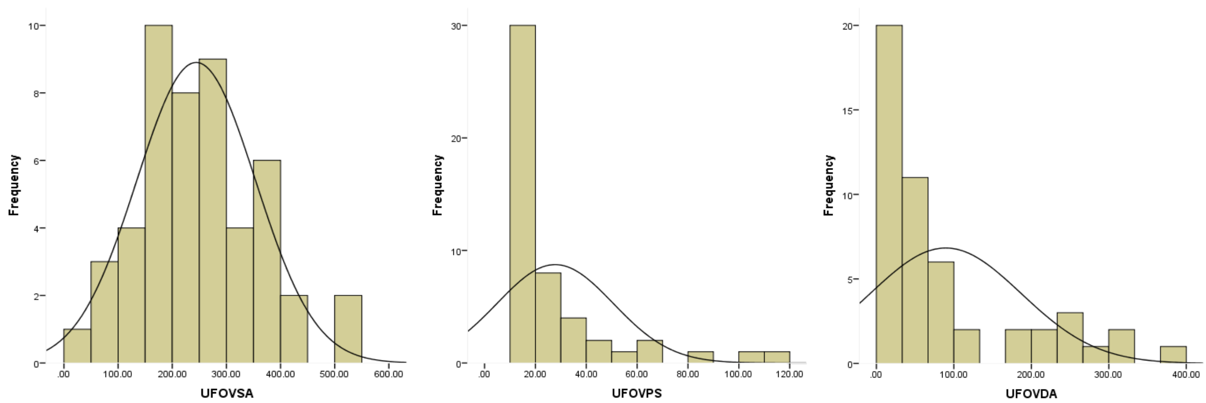


Figure 6.1. Distribution of Scores for All UFOV Subtests (milliseconds)

All data met the assumption of independent errors (Durbin-Watson values ranged from UFOVPS = 1.769, UFOVDA = 1.810, UFOVSA = 1.974). Among the predictor variables, Conjunction Search – Reaction Time, RSPM and DBQ Violations were also skewed. However, it is usual to have a positively skewed distribution for reaction time, particularly when a decision is required (Hockley, 1984). Further, most participants performed above the norm for their age group in the RSPM resulting in a negative skew for that data. Rather than transformation, bootstrapping (1000 samples) was performed in each regression to compensate for failure of the assumption of normal distribution, linearity and low variance in the data and to compensate to some extent for a small sample size (Field, 2013). The histogram and P-P plot of standardised residuals for UFOVSA indicated all data contained approximately normally distributed errors. Figure 6.1 indicates the distribution of each of the UFOV subtests. All other data met the assumptions of normality, linearity, multicollinearity, and homoscedasticity.

DBQ Factor Analysis

A factor analysis was conducted on the responses for the DBQ to confirm that the factors emerging in this group were similar to that demonstrated in other studies. In particular, Reason and colleagues (1990) identified three factors in their development of the DBQ and Parker and colleagues (2000) later identified five factors in a group of older drivers. All respondents in this study completed the 24 questions on two occasions, six weeks apart with the exception of one participant who failed to complete the second questionnaire resulting in 99 complete scores. Table 6.2 shows the mean responses and standard deviations for each of the items on the DBQ.

The 24 items were subjected to exploratory factor analysis. Given the small sample size, the suitability of data for analysis was assessed using the Kaiser-Meyer-Olkin Measure of sampling adequacy, which was .7 and greater than the minimum .6 so the sample was acceptable. Also, Bartlett's Test of Sphericity (Bartlett, 1954), X^2 (276) = 718.86, $p < .001$ confirmed the factorability of the correlation matrix. Principal axis factoring indicated seven factors with eigenvalues greater than one, which explained 62% of the variance overall. However, inspection of the scree plot indicated a clear break after the third factor. Parallel Analysis (Horn, 1965) confirmed only three factors with eigenvalues exceeding the criterion values for a randomly generated data matrix of the same size (24 variables x 50 respondents x 2). The three-factor solution (refer to Table 6.2) explained a total of 41.1% of the variance (Factor 1 - 22.5, Factor 2 - 9.5, Factor 3 - 9.2%). Finally, Oblimin rotation revealed a simple structure with all variables loading strongly, with each loading only on one Factor.

Table 6.2. Factor Structure and Loadings over .30 with Oblimin Rotation of the Driver Behaviour Questionnaire

Factor 1	Errors	Loading	M (SD)
Q4	Fail to check the rear-view mirror before pulling out, changing lanes, etc.	.61	0.70 (0.72)
Q5	Fail to notice pedestrians crossing on turning into a side road.	.61	0.76 (0.64)
Q1	Underestimate the speed of an oncoming vehicle when overtaking	.60	1.00 (0.61)
Q2	Brake too quickly on a slippery road, or steer the wrong way into a skid	.60	0.79 (0.61)
Q8	Attempt to overtake someone you had not noticed to be signalling a right turn.	.55	0.43 (0.52)
Q6	Miss give-way signs, narrowly avoiding colliding with traffic having right of way.	.55	0.61 (0.55)
Q7	On turning left, nearly hit a cyclist who has come up on your inside.	.48	0.64 (0.68)
Q3	Queueing to turn left onto the main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front	.45	0.81 (0.67)
Q15	Hit something when reversing that you had not previously seen	.34	0.88 (0.66)
Q16	Attempt to drive away from traffic lights in too high a gear	.34	0.32 (0.57)
Factor 2	**Lapses**	**Loading**	**M (SD)**
Q12	Realise that you have no recollection of the road along which you have been travelling	.74	1.3 (0.87)
Q11	Forget where you left your car in a carpark	.71	1.58 (0.99)
Q13	Intending to drive to destination A, you suddenly notice that you are on the road to destination B	.64	1.25 (0.83)
Q9	Misread the signs and take a wrong road off a roundabout	.47	1.22 (0.68)
Q14	Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers.	.37	1.27 (0.74)
Q10	Get into the wrong lane approaching a roundabout or junction	.32	1.42 (0.61)
Factor 3	**Violations**	**Loading**	**M (SD)**
Q22	Drive, even though you realise you may be over the legal blood-alcohol limit	.72	0.35 (0.61)
Q20	Drive especially close to signal to the driver in front of you to go faster/get out of the way	.586	0.16 (0.42)
Q21	Have an aversion to a particular class of road user, and indicate you hostility by whatever means you can	.55	0.26 (0.51)
Q18	Become impatient with a slow driver in the outer lane and overtake on the inside	.51	0.74 (0.75)
Q19	Cross a junction knowing that the traffic lights have already turned against you	.48	0.55 (0.67)
Q17	Disregard the speed limits late at night or early in the morning	.42	0.97 (0.87)
Q23	Get involved in unofficial 'races' with other drivers	.33	0.09 (0.32

Responses not loading high enough to load onto a factor

Q24 Angered by another driver's behaviour, you give chase with the intention of giving him/her a piece of your mind. M = .04 SD 0.20

n = 99

The three factors identified in this analysis closely agree with Error, Lapse and Violation factors described by Reason and colleagues (Reason et al., 1990) in their early development of the DBQ. The three factors were also very similar to Parker and colleagues' results (Parker et al., 2000) except that Parker's two Violation factors collapsed into one and the two items in Parker's last unnamed factor fell logically into the Error and Violation factors in this analysis. One question (Q24 – *"Angered by another driver's behaviour, you give chase with the intention of giving him/her a piece of your mind"*) was the least indorsed in the set and did not load sufficiently to be included in any factor, so was excluded. Consequently, the three factors and the total raw scores for the DBQ were included as predictors in the regression analysis.

Predicting Performance in the UFOV

Correlations were examined between each of the UFOV tasks and all potential predictor variables with the purpose of developing a multiple regression model to predict performance in each of the three UFOV tasks, UFOVPS, UFOVDA and UFOVSA. A one-tailed correlation was generated for both UFOVPS and UFOVDA due to performance ceiling effects and consequential skewness data for these two variables. A two-tailed correlation was generated for UFOVSA (see Table 6.3).

Table 6.3. Correlations of Predictors With Each UFOV Task

	UFOVPST (1-tailed)	UFOVDA (1-tailed)	UFOVSA (2-tailed)
Age	-.046	.25*	.52**
n	50	50	49
Education	.019	-.14	-.21
n	50	50	49
MoCA	-.12	-.07	-.17
n	50	50	49
RSPM	-.33**	-.28*	-.37**
n	50	50	49
DBQTotal	.30*	.170	-.174
n	50	50	49
DBQErrors	-.049	-.12	-.10
n	50	50	49
DBQLapses	-.06	-.03	-.32*
n	50	50	49
DBQViolations	-.00	-.05	-.07
n	50	50	49
HazardPercept	.05	.07	.09
n	50	50	49
DrivingSkill	.27*	.16	-.01
n	50	50	49
CSRT	.26*	.04	.18
n	49	49	48
CSAc	-.13	-.31*	-.09
n	49	49	48
Accidents	.08	-.04	.13
n	50	50	49
Yrsdriving	-.18	.09	.55**
n	50	50	49
Klmsyrnow	.14	-.09	.09
n	50	50	49
Klmsyrthn	-.08	-.16	.09
n	50	50	49

Note. MoCA = Montreal Cognitive Assessment, RSPM = Raven's Standard Progressive Matrices, CSRT = Conjunction Search RT, CSAc = Conjunction Search Accuracy, Accidents = Motor Vehicle Accidents in the last 5 years, Klmsyrnow = Kilometres driven per year now, Klmsyrthn = Kilometres driven per year in peak driving history.
n = 50 (UFOVPS & UFOVDA), 49 (UFOVSA
*. Correlation is significant at the 0.05 level.
**. Correlation is significant at the 0.01 level.

UFOVPS. A multiple regression model which included the four predictors that significantly correlated with UFOVPS (RSPM, DBQ Total, Driving Skills, Conjunction Search – Reaction Time) produced a significant outcome $F(4,44)$ = 4.108, p = .006. Adjusted R^2 = .206. In this model, neither Conjunction Search – Reaction Time nor Driving Skills made a significant contribution. However, Adjusted R^2 dropped to .187 when both predictors were removed. Finally, Adjusted R^2 increased beyond the original model when Conjunction Search – Reaction Time was added back into the model thus explaining 22% of total variance in UFOVPS, $F(3,45)$ = 5.487, p = .003, Adjusted $R^{2=}$ .219 (see Table 6.4). Multicollinearity between predictors was assessed via the variance inflation factor scores (VIF), all of which fell between 1.086 and 1.211. These scores confirmed the absence of correlation between each of the independent variables in this final model.

Table 6.4. Regression of Predictors on UFOVPS Performance

			Bootstrap[a]					
		Adjusted					CI	
Model	R^2	R^2	B	SE	t	p	Lower	CI Upper
	.27	.22						
Constant			.03	.04	1.23	.35	-.05	.11
RSPM			-.00	.00	-2.38	.14	-.02	.00
DBQ Total			.00	.00	2.72	.06	.00	.00
CSRT			.00	.01	1.70	.25	.00	.00

Note: UFOVSA - Useful Field of View Processing Speed subtest, RSPM - Raven's Standard Progressive Matrices, DBQ - Manchester Driver Questionnaire, CSRT - Conjunction Search Reaction Time, CI - 95% Confidence Interval.
[a]Bootstrap results are based on 1000 bootstrap samples.

UFOVDA. Age, RSPM, and Conjunction Search-Accuracy all correlated significantly with UFOVDA (see Table 6.5). However, the multiple regression model generated with these predictors fell just short of significance $F(3,45)$ = 2.737, p =

.054, Adjusted $R^2 = .098$. After dropping Age, the model did reach significance and now included RSPM and Conjunction Search-Accuracy and explained a total of 9.5% of the variance in UFOVDA $F(2,46) = 3.516$, $p = .038$, Adjusted $R^2 = .095$, however none of the predictor coefficients reached significance (refer to Table 6.5).

Table 6.5. Regression of Predictors on UFOVDA Performance

	R^2	Adjusted R^2	B	Bootstrap[a] SE	t	p	CI Lower	CI Upper
Model 1	.15	.10						
Constant			.82	.46	1.69	.08	-.09	1.70
Age			.00	.01	-1.30	.30	-.00	.01
RSPM			-.00	.00	1.08	.45	-.01	.00
CSAc			-.83	.54	-1.71	.15	-.177	.28
Model 2	.13	.10						
Constant			.82	.46	2.32	.05	-.02	1.88
RSPM			-.00	.00	-1.44	.26	-.01	.00
CSAc			-.83	.54	-1.78	.13	-1.75	.32

Note: UFOVDA - Useful Field of View Divided Attention subtest, RSPM - Raven's Standard Progressive Matrices, CSAc - Conjunction Search Accuracy.
[a]Bootstrap results are based on 1000 bootstrap samples.

UFOVSA. The four predictors with significant correlations with UFOVSA were Age, RSPM, DBQ-Lapses and Years Driving. However, Age and Years Driving were significantly correlated ($r = .877$, $p < .001$) so Age was retained in the model. The ENTER method provided a significant model $F(3,45) = 9.531$, $p > .001$, Adjusted $R^2 = .348$, and resulted in all predictors reaching significance (see Table 6.6).

Table 6.6. Regression of Predictors on UFOVSA Performance

				Bootstrap[a]				
Model	R^2	Adjusted R^2	B	SE	t	p	CI Lower	CI Upper
	.39	.35						
Constant			.10	.18	0.05	.96	-.33	.39
Age			.01	.00	3.37	.005	.00	.01
RSPM			-.00	.00	-1.73	.03	-.01	.00
DBQ-Lapses			-.06	.02	-2.50	.008	-.109	-.02

Note: UFOVSA - Useful Field of View Selective Attention subtest, RSPM - Raven's Standard Progressive Matrices, DBQ - Manchester Driver Questionnaire.
[a]Bootstrap results are based on 1000 bootstrap samples.

Discussion

The aim of this study was to identify some of the cognitive and perceptual elements that contribute to the success of the UFOV test as a predictor of driving capability in older adults. The predictors selected were categorised as: *Driver Attitude and Confidence* (Perceptions of Driving Skills Questionnaire, Hazard Perception Questionnaire and the DBQ); *Global Cognitive Functioning* (MoCA); Intelligence - visual (RSPM); *Perceptual Skills* (visual search – Conjunction Search - Reaction Time and Conjunction Search - Accuracy) and; *Demographics and Driving History* (age, education, number of motor vehicle crashes in the last five years, kilometres driven at the peak of driving history and kilometres driven now).

UFOV Subtest 1 – Processing Speed

The final model, which included RSPM, DBQ-Total and Conjunction Search-Reaction Time, predicted 22% of the total variance in performance. Among the individual predictors, only DBQ Total was approaching significance (p = .06). However, a statistically significant multiple regression model without significant coefficients indicates that individually, none of the predictors singularly explain the variance in UFOVPS, but collectively, all the predictors contribute to the identified variance. This may be explained by the variance in UFOVPS itself being very close to zero (.001) likely due to 62% of the total sample scoring at ceiling which is similar to the proportion at ceiling in the UFOVPS in the Matas et al. (2014) study (61%). The effect of such a high proportion of ceiling scores is to question the validity and restrict the interpretability of these results because it most likely conceals evidence of any significant predictors. Therefore, these results are interpreted with caution. That, combined with the low power in this study (50 participants), may well have resulted in a significant model without clear individual predictors. Notwithstanding, it was expected that Conjunction Search-Reaction Time would be included in the final model as UFOVPS has been categorised largely as a speeded object discrimination task (O'Brien et al., 2015) although Matas et al. (2014) found that results were better explained by visual acuity and contrast sensitivity rather than processing speed. DBQ-Total correlated positively with UFOVPS indicating that the more driver errors a participant reported overall, the higher their score on UFOVPS (slower response time to achieve 75% accuracy). A similar result was reported by López-Ramón, Castro, Roca, Ledesma, and Lupiañez (2011) when they found that those who reported a higher number of lapses on the Attention-Related Driving Error Scale, a scale developed to examine specific attentional lapses when driving (Ledesma, Montes, Poó, & López-Ramón, 2010), also had slower reaction times on the Attentional Networks Test (Fan, McCandliss, Sommer, Raz, & Posner, 2002) providing support for the outcome in this analysis. Lastly, participant scores for the RSPM negatively correlated with UFOVPS indicating that the better performance on RSPM (more items answered correctly), the lower the score on UFOVPS (faster response time to achieve 75% accuracy). RSPM is described as a test of non-verbal abstract reasoning which, if the relationship is reliable, suggests that reasoning ability may contribute to UFOVPS performance. Alternatively, in their exploration of RSPM performance, Lynn, Allik, and Irwing (2004) identified both gestalt continuation and spatial ability as factors that contributed to performance in their sample of 2,735 12-18 year old adolescents. The stimulus in UFOVPS is a white figure of a car or a truck on a black background, the only difference between the two figures being a single line that differentiates the roof line of the car from the tray back of the truck (refer to Figure 3.4 in Methods Chapter) so it is likely that discrimination between the two figures may tap into gestalt continuation or closure. Additionally, both UFOV and RSPM are visual tests so it may be that the visual component of each is the source of this relationship. Visuospatial ability may have also made some contribution to performance along with visual acuity and contrast sensitivity (Matas et al., 2014) although all participants reported normal or corrected to normal vision as tested within the last two years. Although RSPM as a predictor of UFOVPS was not significant, the potential for visual or other cognitive elements being a possible contributor to UFOV performance as a proxy driving measure, may be of interest for further research.

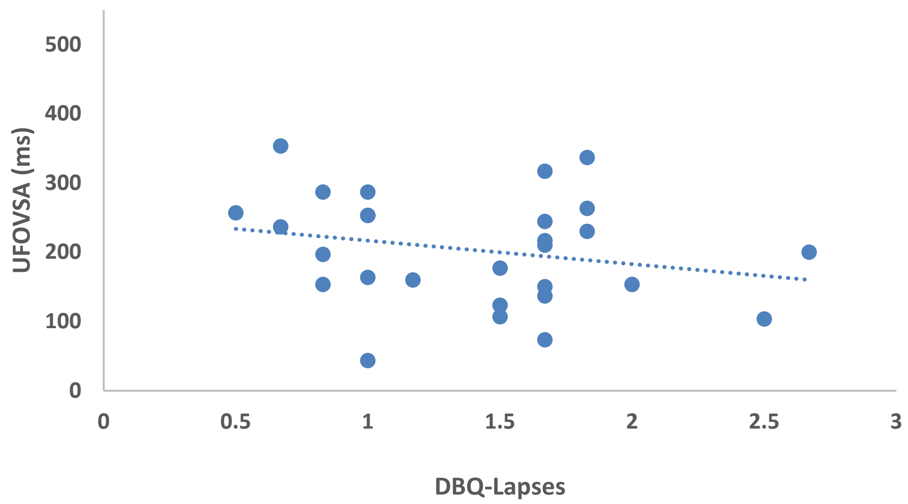
UFOV Subtest 2 – Divided Attention

Although a number of predictors were significantly correlated with UFOVDA, the model including RSPM and Conjunction Search – Accuracy was the only one that reached significance and it explained 9.5% of the variance in performance, although the model that was approaching significance included age among the predictors. Again, despite these models being significant, or nearing significance, none of the coefficients was individually significant. As with the UFOVPS, the results for UFOVDA had ceiling effects (26% of participants performed at ceiling) resulting in skewed data and low variance which, along with a small sample size, likely contributed to the lack of significance of the predictor variables, and this makes this outcome difficult to interpret. Notwithstanding, Conjunction Search – Accuracy was negatively correlated with UFOVDA which indicated that those with higher accuracy in conjunction search were also faster at UFOVDA. This result contravenes the prediction that if a speed-accuracy trade-off strategy was engaged with conjunction search such a strategy would also be followed with the UFOVDA task resulting in a slower reaction time to reach 75% accuracy. However, these results do suggest that, within this sample, overall performance was fast *and* accurate. Given the small amount of variance explained by the model, this result may in fact be an anomaly of the data rather than a reliable relationship. Further investigation into this relationship with a larger sample may shed some light on this result. Interestingly, RSPM predicted performance in UFOVDA but again because there is so little variance explained by the model, it may be that the visual components of RSPM are behind the relationship. RSPM as a potential predictor of UFOVDA and UFOVPS is discussed further in the general discussion below.

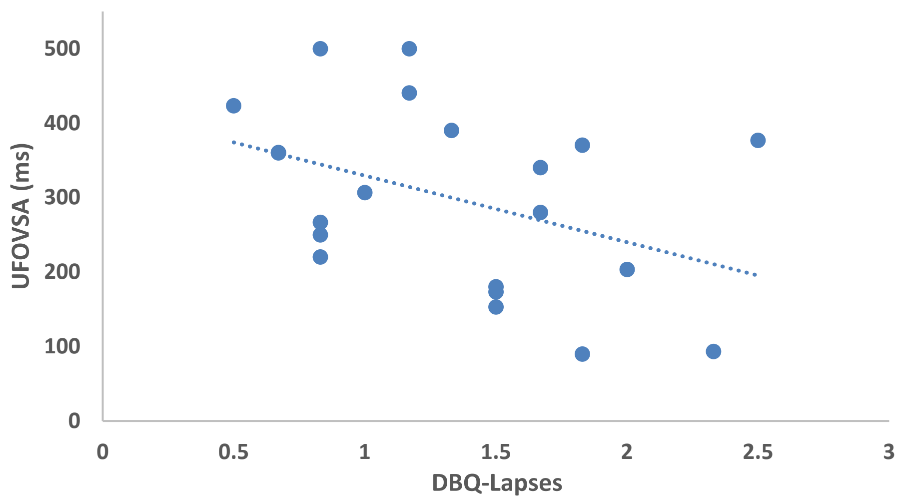
UFOV Subtest 3 – Selective Attention

The model that included Age, RSPM and DBQ-Lapses explained 35% of the variance in UFOVSA and each made a significant contribution to the model. UFOVSA has been described as a test of performance in a visually crowded environment (O'Brien et al., 2015), contrast sensitivity, processing speed, and general cognitive ability (Matas et al., 2014). Visual crowding and contrast sensitivity were not tested in the current sample, however unlike previous studies (Matas et al., 2014; Mathias & Lucas, 2009), processing speed (Conjunction Search - Reaction Time) and general cognitive ability (MoCA) did not predict UFOVSA performance. Interestingly, UFOVSA was the only subtest where Age predicted performance, possibly due to a more normal distribution of results without ceiling effects allowing true predictors to emerge. This relationship was expected and concurs with findings from Willstrand et al. (2017) who found that the older the driver, the slower their performance on UFOVSA and the more on-road errors they made. Lunsman et al. (2008) also found that age predicted both initial performance on the UFOV Test and rate of change over time with older age indicating poorer initial performance and greater decline over time.

DBQ-Lapses include items such as "*Realise that you have no recollection of the road you have been travelling*" and "*Intending to drive to destination A you find yourself headed for destination B*" supporting the categorisation as a failure of attention (Roca, Lupiáñez, López-Ramón, & Castro, 2013). Of considerable interest is that DBQ-Lapses and UFOVSA were negatively correlated meaning those with poorer performance (slower) on the UFOVSA also had fewer self-reported lapses of attention. Although unexpected, this result may be explained by the findings in Willstrand et al. (2017) whose older participants made attentional errors such as: failing to attend to the right, left, and to other road users; driving at higher speeds through high pedestrian areas; and failure to attend to road signs, traffic lights road markings and their rear-view mirrors during an on-road driving test. This lack of attention to such things in a test situation with observers in the vehicle may suggest a lack of insight into their errors which may translate into a lack of insight in other situations of attention lapses. To explore this further, a comparison of older and younger UFOVSA performance in the current sample clearly indicated that the negative correlation between UFOVSA and DBQ-Lapses was driven by those 75 years and older (refer to Figure 6.2). Although this correlation was only approaching significance ($r = .412$, $p = 0.63$), the relationship is quite clear suggesting that increasing the sample size specifically to compare the two age groups (under and over 75 years) may well provide a more concrete demonstration of this finding and the ability to explore this further.



a)



b)

Figure 6.2. Scatterplot of UFOVSA Performance and DBQ-Lapses for Those Participants (a: Under 75 years (n = 28) and (b: Over 75 years (n = 21)

Once again, RSPM featured in the model that predicted performance in this subtest. However, unlike UFOVPS and UFOVDA, the data for UFOVSA are not beleaguered by ceiling effects and distribution problems suggesting that this relationship is more reliable and certainly more interesting. There is considerable evidence to support a link between fluid intelligence and attention (Schweizer, Goldhammer, Rauch, & Moosbrugger, 2007; Schweizer & Koch, 2003; Schweizer & Moosbrugger, 2004; Schweizer, Moosbrugger, & Goldhammer, 2005), particularly attentional control which is engaged in effortful mental processing (Schweizer, 2010) and suggests that attentional control may be the critical element in this relationship. Notwithstanding, RSPM is clearly a visual task suggesting that the visuospatial elements that contribute to performance in RSPM are also engaged in UFOVSA.

General Discussion

This study may have benefited from a greater number of participants. Both Matas et al. (2014) and Willstrand et al. (2017) were able to get good variance from all UFOV subtests that explained a significant amount of variance with 80 participants, 30 more than this study. However, Willstrand and colleagues' sample was older with an age range starting at 70 years, with the average age being 77.4 for males and 75.3 for females. Matas and colleagues' sample was very similar to those in the present study, and also produced ceiling effects in UFOVPS, but not so in UFOVDA. The sample in the present study clearly found UFOVPS too easy and were performing at ceiling and there was insufficient variance in UFOVDA results to provide a clear relationship with predictors. Further, comparisons with normative data for the three UFOV tasks also indicated that this sample of participants performed better (faster) in both the UFOVPS and UFOVDA tasks than the norm but within expected limits for UFOVSA (Edwards et al., 2006). Therefore, given that adding participants to make up a larger sample would have meant they were drawn from the same local population and so may have produced proportionately similar effects.

Given that the objective of this component of the overall study was to identify what it is that makes UFOV a good predictor of driving ability, it was of interest that RSPM emerged as a predictor across all subtests. The increasingly challenging series of puzzles in the Raven's tests each reflect an ability to develop and maintain rules in working memory, maintain goals, and the ability to form abstractions (Carpenter, Just, & Shell, 1990), as well as the ability to learn, update and apply rules while inhibiting intrusions from task-irrelevant stimulus, and lastly, to stick with the task at hand (Ren, Schweizer, Wang, Chu, & Gong, 2017). Evidence from neuroimaging studies indicated that performance on RSPM requires the engagement of the prefrontal areas, particularly the dorsolateral prefrontal cortex (Lezak et al., 2012) confirming that RSPM has a strong working memory dependence (Gonthier & Roulin, 2019). These drivers of RSPM performance may also be engaged when doing the UFOV subtests. Although many of the current participants found the first two UFOV subtests easy, comments from many during testing differentially reflected the difficulty and challenge of the UFOVSA task. Hypothetically, it may be that those who managed to learn from the first two tasks, then settle into the UFOVSA task, resist distractors, and apply the task specific updated rules (as they did in the RSPM task) were most likely to do well. Perhaps also, the prolonged attentional endurance and the rule-shifting requirements of the RSPM explain why it was this task that better aligned to UFOVSA and UFOVDA, rather than education (the participants in this study had a high level of formal education; $M = 16.2$, $SD = 3.2$ yrs) which may have represented the local population's high regard for education rather than intelligence per se. Therefore, the relationship between intelligence and the UFOV test may be an interesting area for future research. Notwithstanding, RSPM, Conjunctions Search and each of the UFOV subtests are visual tasks with spatial components which may be the basis of the relationship between RSPM and UFOV.

Of interest is a study by Vallesi (2016) looking at the predictors of dual-task costs in older adults that found that formal education predicted around 25% of the variance in his sample. Vallesi's analysis also included cognitive ability (MoCA) which, as per this study, did not singularly add to his model. However, unlike Vallesi's model, education was not a predictor in the current model, which may be explained by the nature of Vallesi's task that was heavily working-memory dependent, whereas the UFOVDA task is very much a visual attention task only with little, if any, working-memory load.

In summary, a lack of power may have constrained the ability to identify some important relationships in this study. However, some interesting findings emerged including a potential relationship between fluid intelligence and the UFOV Test. Additionally, the relationship between self-reported attentional lapses and UFOV performance as age increases, supports the finding that older drivers may lose insight into their driving shortcomings. Each of these findings suggest an interesting area for future research.

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Chapter 7: Summary, Implications and Conclusions

Thesis Summary

The term *successful ageing* encapsulates quality of life for older people. Not only does successful ageing imply an absence of disease and disability, but also the endurance of cognitive functionality that allows active engagement in life, and the ability to adapt to change (J. W. Rowe & Kahn, 1997, 2015; Von Faber et al., 2001). A key element of successful ageing is independence; the ability to care for oneself. This relates to all areas of normal activity including the ability to: go shopping; to manage medications, finances, and housekeeping; and to get to places and people, be it via public transport, a lift with a friend, or to drive themselves. For older people, a loss of independence frequently leads to social isolation via loss of connectedness and relationships with friends and family, and then to depression and frequently, to cognitive decline (Cabrita, Lamers, Trompetter, Tabak, & Vollenbroek-Hutten, 2017). Such decline has adverse implications for individuals and family members, but also economic implications, as institutional care is costly to provide.

Importantly, maintaining independence for older people relies on cognitive health. The cornerstone of all cognitive function is attention (Verschooren & Egner, 2023). The ability to focus on relevant stimulus, while ignoring everyday distractions, or to have a conversation while doing something else at the same time, are the fundamental actions of attention that we take for granted every day. Failure of attention in these situations can result in distraction, memory lapses and forgetfulness, simply due to an inability to focus attention (A. Gazzaley, Cooney, Rissman, & D'Esposito, 2005). Because driving is an activity that engages all attentional functioning, changes in driving ability are frequently the harbinger of cognitive decline that prove difficult for older people. Driving, particularly in countries such as Australia, is the main form of transport to the extent that it becomes part of one's identity. So, the loss of one's driving licence, or the realisation that driving has become too difficult, can be a devastating milestone in ageing, particularly given the negative implications for autonomy, independence, and social connectedness. Impairment in cognitive functions due to normal ageing is common and, for some, inevitable, but equally, the motivation to maintain or to regain brain health has been buoyed along by the promise of improvement. Among the increasing selection of activity and lifestyle changes recommended for healthy, successful ageing, is cognitive training.

Aim of this study

The core of this thesis is the examination of targeted, attention-focused cognitive training delivered to a group of older adults with the aim of training gains improving performance on a series of untrained tasks – the three tasks in the Useful Field of View (UFOV) test. The distinction for this research is this transfer of training gains rather than the simple improvement on the trained tasks. This aim was clearly met in the UFOV Divided Attention task. Unfortunately, it was also found that practice effects overwhelmed any detectable cognitive improvements in the more challenging UFOV Selective Attention task. At the other end of the spectrum, significant ceiling effects in the UFOV Processing Speed task at best indicated that this task was too easy overall and therefore unable to demonstrate any improvement. These results, as they relate to each UFOV task, are examined in more detail below.

Why is this study important?

As background, video games have become popular as a tool for cognitive rehabilitation, but there has been mixed results in regards to generalised cognitive gains for older people, with *brain fitness* commercial programs generating the least improvements (Belchior et al., 2013; Boot et al., 2013; Kable et al., 2017). While popular action video games may produce significant increases in untrained cognitive measures post-training (e.g. Perrot, Maillot, & Hartley, 2019), there is little exploration of the active ingredient of these interventions. There have also been video games specifically targeting cognitive improvement for older people, and these games have demonstrated enhancement in the targeted cognitive functions (e.g. Anguera et al., 2013; Anguera et al., 2021), but these programs are not easily accessed by older people outside research participation. Therefore, this study was designed to administer relatively simple attention-based tasks (such as visual search) for training, and to explore the likelihood of transfer of training gains from those tasks to a proxy measure of driving risk. Thus, if this goal was achieved, it would be a simple task to build a similar online version of the attention training tasks that could be easily available to older people.

Hypotheses

In this study, it was expected that, after online attention training, any training gains would transfer to the sub-tasks of the UFOV® Test: one of the most extensively researched assessments of motor vehicle accident risk for older drivers (Wood & Owsley, 2014). In comparison, it was expected that training on working memory tasks would not generate the same transfer benefits compared with the attention condition. The UFOV Test has three sub-tasks each aimed at different components of attention, *processing speed, divided attention,* and *selective attention,* and as such, results of the training intervention for each of these sub-tasks was examined individually: the results for each task confirming the appropriateness of this approach.

Additionally, to explore possible predictors of UFOV performance for this group of participants, several sources of individual differences were investigated. These variables were grouped into the following categories: driver attitudes and confidence; global cognitive functioning; perceptual skills; driving history; and demographics. Examination of these variables and their effect on performance on the UFOV tasks provided some interesting findings that are discussed later in this chapter.

An important departure from most cognitive training research is that the 14-day training program was designed to be accessed by the participants in their own time, in their own home, and on their own computer, via two purpose-built web sites that captured details confirming each training event completed by each participant. Although the Covid-19 pandemic has subsequently made such methods more common, the intent in this study at the time was to make the training more flexible, accessible, and enjoyable to increase motivation and compliance of the participants. The completion rate for the training across participants was 88%, confirming that this goal was largely met.

The research questions (restated below) are discussed in relation to the key results from the each of the experimental chapters, namely the outcome of transfer of cognitive training gains to the UFOV Test. This chapter will also discuss the implications of these findings and how they can best be interpreted in relation to the greater literature around older people seeking to regain or maintain cognitive health.

The discussion will then examine the limitations of the research along with ideas for future research opportunities.

Research Question: Examine the importance of attention as a key component of cognitive training via the extent of transfer of training gains from attention training to each of the three tasks of the UFOV Test – an assessment of driving risk for older adults.

To address these questions 50 community-dwelling adults (*M* = 73.6 yrs, *SD* = 7.3; 48% female) volunteered and were recruited. Participants completed three lab-based sessions where the UFOV Test was administered, the 14-day period between Times 1 and 2 serving as a within-subjects control condition. Participants were then allocated to two intervention groups, one doing attention-based training over the 14-day training intervention period, and the other working memory training, this group being a comparison control group. It was expected that the Attention group would significantly improve performance on each of the UFOV Test subtasks after the intervention, because the UFOV Test is an attention-based assessment, and therefore near-transfer. The improvement in performance between Time2 and Time3 for the Attention group was expected to be significantly greater than any improvement in UFOV performance for the Working Memory group.

UFOV Divided Attention

This task builds on the first UFOV task (discussed at the end of this section) with participants simultaneously doing the processing speed task, while also having to identify the location of another object (a car) in one of the eight peripheral locations. This task targets divided attention performance (also known as dual task). In the UFOV Divided Attention task (UFOVDA), presentation time is again used to control reaction time by limiting the duration of the stimulus image which ranges from 16.7 ms (fastest refresh rate of an average personal computer) to 500 ms, the longest time the stimulus is available.

As expected, during the 14-day control period (between Time1 and Time2) there was no significant change in UFOVDA performance. However, results clearly showed significant improvement in the UFOVDA task after the training intervention, which supported the hypothesis that there would be transfer of training gains from the 14-day, home-based training to UFOVDA. These results were clear despite the moderate ceiling effect that emerged over testing. Unlike UFOVPS (discussed below), these ceiling effects did not distort the final results.

However, contrary to the hypothesis that those in the Attention training group would show a clear training advantage over those in the Working Memory training group, performance improvement between the two intervention groups was not significantly different, with the Working Memory group also showing transfer of training gains to UFOVDA. This outcome will be discussed in more detail after the results of each of the UFOV tasks have been summarised.

UFOV Selective Attention

The UFOV Selective Attention (UFOVSA) task was reported as being the most difficult by participants. This task again builds on the two previous UFOV tasks in that participants must discriminate between a car and a truck at fixation while simultaneously identifying the location of a car in the periphery. However, the addition of 47 triangles, the same colour, size and luminance of the targets, makes the task particularly challenging. The UFOV authors identified the triangles as visual distractors (Ball et al., 1988; Wood & Owsley, 2014); the ability to ignore these distractors is a key function of selective attention.

The results of the UFOVSA again did not differ across the two intervention groups with the Working Memory group performing similarly to the Attention group. However, for all participants there was a clear practice effect over the control period (between Time1 and Time2) when no training activity was undertaken. As per UFOVDA results, there was an improvement in performance after the training intervention, but the change was not significantly different to the improvement during the control period and so further practice effects could not be ruled out.

Although the likelihood of practice effects had been dismissed when the authors tested the UFOV Test for reliability and validity (Edwards et al., 2005), a subsequent interrogation of the literature revealed similar practice effect, but in a younger group, reported by Bentley et al. (2012) in their investigation of UFOV performance of glaucoma patients. Included in the testing were two separate groups (one young adult group, n=13, mean age=28 yrs; and the other older adults, n=21, mean age=66 yrs) who did a test/retest 14 days apart. Both groups had clear practice effects but only the improvement in the young adults' group was significant. The older group's improvement was reported as approaching significance, but important to note is that the older group was younger than those in this experiment (this effect is discussed in detail in Chapter 5). Otherwise, extensive search in the current relevant literature reveals no additional reports of practice effects for the UFOVSA.

Although the expected outcome of training transfer to the UFOVSA task in the present study's sample was not realised, the results were interesting in that they identified a shortcoming of the UFOV Test for older adults, not previously identified. Therefore, further investigation into practice effects for older adults doing the UFOVSA task would assist in interpreting the reliability and validity of this task as an assessment of driving risk in this population and add to the considerable bank of research around the UFOV Test.

UFOV Processing Speed

The first UFOV subtest is the UFOV Processing Speed task (UFOVPS) which is a simple, speeded, object-discrimination task that required the participant to determine if the object presented at fixation was a car or a truck. A clear ceiling effect dominated the results of the UFOVPS as indicated by the average score across all participants and all trials being 75% accuracy at the minimum possible time of 16.7 ms. There was improvement across trials but again, this was clearly uninterpretable due to the already high performance across participants. To examine the results for those participants *who did not* reach ceiling, the ceiling scores were removed from the sample. This left scores for 11 out of 50 participants (37 out of 150 data points), clearly insufficient for meaningful analysis. Therefore, no further analysis was carried out for this component of the experiment. However, the data was retained for the prediction study.

Attention Versus Working Memory Training

The main hypothesis included the prediction that performance on the UFOV tasks would improve after the intervention, demonstrating transfer of training gains. However, imbedded in that was the expectation that those improvements would be greater for those participants in the Attention training group compared with those training on a set of non-attention tasks. Contrary to this expectation, both groups improved and there was no significant difference in training outcome between the two groups, hence the results for the two groups were combined and analysed together. The training tasks allocated to the non-Attention group were all working memory training tasks, matched to both the lab-based tasks and the attention tasks on difficulty, duration, and engagement. Unexpectantly, there was clearly a training (intervention) effect for the Working Memory group similar to that of the Attention group, suggesting that the working memory tasks were possibly also tapping attention resources. The three working memory tasks were specifically selected for their impact on working memory over attention functions and included firstly a card game where participants had to hold their score in mind while making decisions about their next move. It is unlikely that this task required additional attention to complete, as all information was available on the screen, and a simple decision, based on available information (and their memory of their current score), was the output. The Dot Estimation task, again recognised as targeting working memory processes (Gandini et al., 2009; Tuholski et al., 2001) may have engaged some attentional resources but the target dots were available for sufficient time for viewing, judgement and comparison (1000 ms) and so an investment of attentional resources sufficient to lead to the current outcome, was unlikely. However, Digit-Span-Forward and Backward (both well-recognised working memory tasks; Lezak et al., 2012) were chosen to match the difficulty of the UFOV task; specifically, Digit-Span-Forward matched the divided attention component in the UFOV (refer Chapter 3 – General Methodology) and Digit-Span-Backward was matched to the difficulty of the UFOVSA task, again recognising that UFOVSA was found to be difficult and surprising in pilot testing. However, it may be that the Digit-Span-Backward activated an attention component in this older sample that potentially likened the Working Memory group's performance to that of the Attention group. It is noted that Digit-Span-Backward has been cited as being a measure of attention and executive function in children (Hale, Hoeppner, & Fiorello, 2002), however, St Clair-Thompson and Allen (2013) found that for young adults Digit-Span-Backward placed little demand on attentional resources. Also, there has been no evidence in the literature that older adults engage attention resources when doing Digit-Span-Backward. Of interest is that Gajewski, Hanisch, Falkenstein, Thönes, and Wascher (2018) found that older participants engaged attentional processes, rather than working memory resources, when doing an n-back task, another test traditionally used to measure working memory across the lifespan. This last finding suggests that older people may engage different processing strategies to those of younger people in these kinds of tasks, an idea that may be supported by the neural dedifferentiation or the processing speed theories of age-related brain changes (McDonough et al., 2022; Neubeck, Karbach, & Könen, 2022). This may explain the unexpected training effect found in the Working Memory group in this study and it provides an interesting topic for future investigation.

When designing this experiment, the n-back was considered as an alternative to Digit-Span-Backwards as a potential working memory task to match difficulty and timing with UFOVSA. However, although the n-back task has face validity for assessing working memory, it has been found to better correlate with executive functions such as attentional shifting, inhibition of response, fluid intelligence and selective attention, rather than with short-term memory and working memory span (Jaeggi, Buschkuehl, Perrig, & Meier, 2010). Other than n-back and Digit-Span, no other validated working memory task was found suitable as an at-home training task to match the difficulty and timing of the UFOVSA task and so Digit-Span was included.

Research Question: Explore and identify individual differences that predict performance on the UFOV Test.

The evidence presented in this thesis adds to the growing body of knowledge around supporting older people to maintain cognitive health and independence, through cognitive training. In particular, the results of the studies provide clear evidence that transfer of training gains can be achieved for an older population, but more importantly, that these benefits can be realised with simple, relatively easily accessible training tasks that target specific cognitive abilities. An important benefit of this finding is that cognitive training programs can be developed, not only with features of enjoyment and convenience via video games, or just online, but the active ingredient – *attention* can be incorporated as the major conduit for transfer of training gains to cognitive functions that support older people in their activities of daily living.

It was confirmed that convenience and easy access to the training program were effective components of cognitive training for older people and access via a secure website meant their home computer became their training ground. The high compliance rate suggests that being able to complete the training at their own convenience, rather than having to attend a location away from home for their daily brain exercise, increased their likelihood of doing the training regularly and in accordance with the project requirements.

Some interesting findings about further age-related changes in cognitive function were identified, including that insight into cognitive deficits declines as people approach older-old age. This finding opens the door to developing age-stratified models to understand and support the cognitive needs of people as they age.

UFOV Performance

As discussed in Chapter 6, according to Mathias and Lucas (2009), older adults' performance on UFOVDA and UFOVSA is more variable than for younger people, meaning for older people, identifying drivers at risk using the UFOV Test, is relatively straightforward. Older people also have higher variability in other tests of cognitive performance such as reaction time, memory performance, set shifting, and fluid intelligence (Laplume et al., 2022; Morse, 1993), and that variability increases with age (Laplume et al., 2022). As such, it was expected that, in the current group of participants, there would be greater variation across the UFOV tasks and that the selected predictors may provide some insight into that variance. It was speculated that attitudes to driving and confidence on the road would reflect on UFOV performance due to lifetime experience of driving. Therefore, data was collected for several variables that are likely to influence both driving capability and UFOV performance, including reaction time and basic visual search, cognitive function, intelligence, and driver attitude (as discussed in Chapter 6).

Variables were grouped into five categories: driver attitude and confidence; global cognitive functioning; intelligence; perceptual skills; and demographics and driving history. These groupings formed the regression model to predict performance in the three UFOV tasks, each of which is discussed below.

Predictors UFOVPS – Processing Speed

Once again, the fact that a high proportion of participants scored at ceiling in UFOVPS meant that there was little variance across scores meaning that validity and interpretability of the results are questionable. In fact, the total variance identified in UFOVPS performance was very close to zero, and so even though a significant model was identified, it is unlikely to be informative. Consequently, no further discussion is warranted, beyond that the ceiling effect and lack of variation has previously been identified in studies of healthy, older adults (Aust & Edwards, 2016; Woutersen et al., 2017).

Predictors UFOVDA – Divided Attention

In the final model, Conjunction Search-Accuracy and RSPM (abstract reasoning – fluid intelligence) were both significant predictors of performance on UFOVDA, albeit only explaining 9.5% of the total variance, however, no other model reached significance. The relationship was puzzling in that Conjunction Search-Accuracy was *negatively* correlated with UFOVDA which translates to participants being fast *and* accurate at both the Conjunction Search task and at UFOVDA. This contravenes the well-held assumption that older adults generally tend to engage a speed/accuracy trade-off where speed is sacrificed in preference to accuracy (Forstmann et al., 2011; Ghisletta, Joly-Burra, Aichele, Lindenberger, & Schmiedek, 2018; Rabbitt, 1979; Starns & Ratcliff, 2010, 2012). This may have been the case, except almost all scores across participants were above 96% accurate, but there was still good variation in speed, which does not support the contravention of the speed/accuracy trade-off. However, after removal of the individual ceiling scores on UFOVDA, examination of the scatterplot clearly indicated that the negative relationship was no longer evident, again suggesting that this was an anomaly of the data. Therefore, this relationship was not explored further.

The remaining weak but significant relationship indicated that higher scores on the RSPM (abstract reasoning – fluid intelligence) were related to better speed/accuracy performance on the UFOVDA. Because this relationship was significant for both UFOVDA and UFOVSA, consideration of this finding is consolidated as part of the Selective Attention discussion below.

Predictors UFOVSA – Selective Attention

The model that included Age, RSPM and DBQ-Lapses explained 35% of the total variance in UFOVSA and each predictor made a significant contribution to the model. The fact that age was also a singular significant predictor of UFOSA performance was fully anticipated and was in line with the findings of Willstrand et al. (2017) and Lunsman et al. (2008) who each identified that age predicted both UFOV performance and on-road errors; specifically, that the older the driver, the poorer their UFOVSA performance and the more on-road errors they made.

As per the findings for UFOVDA, RSPM not only contributed to the best predictor model, but was again a singular, significant predictor of UFOVSA performance (small to moderate relationship). The general understanding is that fluid intelligence (abstract and inductive reasoning, use of figural and semantic relations, and problem solving) declines with age, but that crystalised intelligence (acquired through learning and experience) is largely retained (Horn & Cattell, 1967). Considering the participants who volunteered and then completed between two and four weeks of engagement with the requirements and tasks of the experiment; each was highly motivated. It may have been that those who are intelligent and confident in their ability may be willing to test their driving competence via a test of driver safety. Equally, it could be assumed that those with concerns about their cognitive functioning, or their ability to perform in an experiment, may not have volunteered for such a study. Therefore, there may be a self-selection bias that favoured those with more confidence in their abilities, which may have been a realistic self-assessment for these participants. Perhaps also, the prolonged attentional endurance and the rule-shifting requirements of the RSPM explain why it was this task that better aligned to UFOVSA and UFOVDA, rather than education (the participants in this study had an average of 16 years formal education).

There is considerable evidence to support a link between fluid intelligence and attention (Aubry & Bourdin, 2021; Schweizer & Koch, 2003; Schweizer & Moosbrugger, 2004; Schweizer et al., 2005). One of these links is that of attentional control which is engaged in effortful mental processing (Schweizer, 2010). According to Draheim, Pak, Draheim, and Engle (2022), attentional control is the mechanism by which limited attentional resources are focussed on goal-directed behaviour, and may involve filtering or blocking irrelevant stimuli and behaviours. Of note is that, as part of his discussion of attentional control, Schweizer (2010) identified that in examining components of intelligence, the attentional component often accounts for a small amount of variance and is thus considered insignificant and is discarded. However, without attention to guide and supervise other mental activities (attentional control), results for tasks that assess intelligence may not be as decisive (Schweizer, 2010).

An unexpected but interesting finding was the negative relationship between DBQ-Lapses and UFOVSA suggesting that those who reported fewer lapses of attention were slower on UFOVSA, which seems counterintuitive. Investigation identified a finding by Willstrand et al. (2017) that may help explain this result, specifically for those participants over 75 years of age. A closer look at the data in the present study identified 21 participants over 75 years and the analysis identified that these results alone were driving the negative correlation. In her study, Willstrand found that the older the driver, the more driving errors they made during an on-road assessment, even with an observer with them in the vehicle, indicating a clear lack of attention to the task. This outcome may indicate not only a lack of awareness of their poor driving performance, but also a lack of insight into those lapses. This would explain the negative correlation between UFOVSA and DBQ-Lapses for the participants over 75 years of age – a clear lack of insight into their own performance on the road. As such, this raises some questions and would be an interesting topic for future investigation, particularly given the age-timing of this change, which would suggest age-stratified models looking at similar changes during later ageing.

Summary of Findings and Implications

In summary, the hypothesis regarding attention and transfer of training gains for this sample of older participants was partly supported. Fourteen days of targeted attention training significantly increased performance on a related, but untrained task – the UFOV Divided Attention task – for this group of older adults. This finding also lends support to the method of delivery, that being a web-based cognitive training program accessible to participants in their own home, on their own computer, and in their own time. The success of this delivery method is supported by the 88% training compliance across all participants in the study. There is a good deal of research around cognitive training and transfer of training gains for older people, and this study adds to the bank of evidence available. This hypothesis was not supported for the UFOVSA or the UFOVPS tasks.

Identified predictors of UFOV performance indicated that fluid intelligence predicted performance on both UFOVDA and UFOVSA in this group of participants. However, as discussed in Chapter 6, this may be better interpreted as fluid intelligence being indicative of attentional control. Thus, according to these results, those with greater attentional control were better able to engage with the demands of the UFOV tasks and so perform at a higher level. The main implication of this finding is that, given the association between the UFOV Test and driver safety, testing this construct in older drivers may provide a more accurate indication of driver safety over age alone and so may prove to be a valuable addition to driver assessments.

Another intriguing finding from this study is the implication that those over 75 years may have less insight into their performance on tasks such as UFOV and driving, potentially increasing risks to themselves and others. Again, this finding is only based on this and one other study, but is this finding indicates an important area for future research into age-related cognitive changes.

Contrary to expectations, there was no significant difference in UFOV performance after training, *between* the two training groups. Although performance improvement was not significant for those in the working memory trained group, and they did not improve to the same extent as the attention trained group, there was no significant difference in UFOV performance between the two groups. As discussed in detail in Chapter 4, and above, it is likely that the attentional requirements of the working memory tasks were overlapping with the attention training tasks. It is also likely, based on anecdotal evidence from the participants themselves, that these participants (and those in the Attention group) were highly motivated (Ryan & Campbell, 2021) both to participate and to do well – also supported by the 88% compliance rate. This may have influenced how they approached the tasks, and thus, put all their attention and focus into the training resulting in an inadvertent tuning of attentional function. Regardless, it is important to note that the increase in UFOV performance for the Working Memory group indicates far-transfer, and as such greater transfer distance than those in the Attention group.

Another point, regarding the Attention group having made greater training gains than the Working Memory group, is that preliminary testing identified that those in the Attention group had poorer MoCA scores (cognitive function; 4% lower score for Att, $p = .01$) which could suggest that the Attention group had more room for improvement (Karbach et al., 2017).

Other Findings

Although there are strong opinions and evidence that adaptive training is superior to extended practice type delivery (De Lillo, Brunsdon, Bradford, Gasking, & Ferguson, 2021), the current results provide support for the latter. One of the advantages of the delivery method in this case was that participants became quite competitive with themselves as a result of getting feedback from most training tasks. An example was a comment from a participant who reflected that, over the course of the training period, they were trying to improve both their reaction time and accuracy scores on the conjunction search task, as a personal challenge. Another comment related to practicing the Digit-Span-Backward task before going to sleep, aiming to improve their performance by that means. It is possible that these personal challenges added to the enjoyment of the training, it may also have reflected the competitive nature of this sample of participants. It is speculated that, if the training tasks were adaptive, this spirit of achievement may not emerge as easily for this group. As discussed in Chapter 2, adaptive training can increase motivation via satisfaction with advancement, but equally can be demotivating if the participant feels the tasks are too challenging (Jaeggi et al., 2011). Given that there is little evidence in the literature regarding whether this holds for older adults, this is an interesting area for further exploration, along with the role of feedback in training performance for older adults.

One of the aims of the overall project was to identify training tasks that would inform the understanding of mechanisms of training gains and transfer. The tasks were also to be recognisable as attention targeted tasks, and relatively easy to access by the general community. It was expected that the attention tasks would stand out in the experiment as the driver of training changes. Although this outcome was achieved to some extent, it is interesting that the working memory tasks could also be catagorised as having achieved this goal, however not to the extent of the attention tasks. Therefore, repeating this study, but capturing more data about the training tasks in a larger sample, would be an interesting area for future research.

Limitations and Future Directions

Selection bias is a significant limitation of this study, particularly as those who participated, volunteered rather than being selected at random from the greater population of older adults who drive. Selection bias causes distortion of the data (Martinson et al., 2010), and, as such, the homogeneity of the participants in this group may have contributed to the outcome. Further examination of this may assist in interpreting the results. Much of the data in this experiment was impacted by ceiling and practice effects, but notable that the participants who volunteered were mostly highly-educated, intelligent, healthy, and high functioning (note the RSPM scores in particular), and potentially had little room to improve. In a sample more representative of the population of interest, it is speculated that the data may have been quite different and perhaps provided a greater range across all the characteristics captured in the individual assessments, and also on the UFOV scores. An important observation of cognitive training is that those with lowest cognitive abilities gain the most out of training, and transfer of training gains (Karbach et al., 2017). The current sample was already performing well, so it may be because of self-selection that there was little opportunity for this group to make any significant improvements over their current cognitive functioning. An investigation into a more appropriate recruitment method, followed by a strict adherence to that method, may better capture a sample more representative of the older driving population to take part in a similar study.

One final point regarding this sample of older participants is that given the high functioning nature of this sample, it is encouraging that there was transfer of training gains at all. The fact that the intervention provided a small to moderate effect demonstrates the strength and effectiveness of the targeted training. Running the full experiment again, with a more typical (less robust) group, may produce stronger effects of training and transfer.

Endurance of Training Effects

It is noted that this study was not looking explicitly at the maintenance of training gains across time, due to time and resource limitations. However, as per the ACTIVE study (Rebok et al., 2014; Willis et al., 2006), it would have added to the value of the current results if there was scope to follow participants and review training gains over time. Similarly, in hindsight, providing early opportunities for familiarity with the UFOV subtasks, particularly UFOVSA, may have overcome the practice effect that interfered with any intervention effect that could have been detected. It would also be beneficial to more closely examine the dose of attention training to achieve transfer of training gains, but again, as per the ACTIVE study, to measure any benefits of booster training.

Target Activity

Rather than testing on a computer-based proxy for driving, a valuable enhancement to this experiment would have been to test participants using a driving simulator. It was unfortunate that at the time this experiment was designed, there was not a simulator accessible, and so the UFOV Test, as a demonstrated proxy for driving safety, was a good option. Replicating this experiment on a simulator, or perhaps an on-road driving assessment, may clarify and strengthen the current findings, in addition to further contributing to current research on driving assessments for older adults. However, given the predictive power of UFOVDA and UFOVSA for older driver on-road performance and crash risk (Ferreira et al., 2013; Krasniuk et al., 2022), and that direct training on the UFOV Test has had success in improving driving performance in older drivers (Ball et al., 2010; Roenker et al., 2003), it stands to reason that the improvement on the UFOV Test itself is likely to transfer to on-road driving. Once again, this hypothesis would be an exciting project for future exploration of training transfer, and particularly the UFOV Test.

Conclusion

The ageing of the world population has brought to the fore the need to maintain not only physical but also the cognitive health of our older population, which flows through to the wellbeing of individuals, families and, ultimately, economic health. This research adds new findings to the area of targeted cognitive training and training transference for older people.

The evidence presented in this thesis adds to the growing body of knowledge around supporting older people to maintain cognitive health and independence, through cognitive training. In particular, the results of the studies provided clear evidence that transfer of training gains can be achieved for an older population, but more importantly, that these benefits can be realised with simple, relatively easily accessible training tasks that target specific cognitive abilities. An important benefit of this finding is that cognitive training programs can be developed, not only with features of enjoyment and convenience via video games, or just online, but the active ingredient – *attention* – can be incorporated as the major conduit for transfer of training gains to cognitive functions that support older people in their activities of daily living.

It was confirmed that convenience and easy access to the training program were effective components of cognitive training for older people, and access via a secure website meant their home computer became their training ground. The high compliance rate suggests that being able to complete the training at their own convenience, rather than having to attend a location away from home for their daily brain exercise, increased their likelihood of doing the training regularly, and in accordance with the project requirements.

Some interesting findings about further age-related changes in cognitive function were identified, including that insight into cognitive deficits declines as people approach older-old age. This finding opens the door to develop age-stratified models to understand and support the cognitive needs of people as they age.

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Appendix Ia. Participant Information and Consent Sheet

INFORMATION AND CONSENT SHEET

Title of Study: Cognitive and Higher Order Sensory Training and Improvements in Driving Capability for Older Adults.

Investigators: Iris Carter, BSc (Psychology) (Hons)
(Clinical Psychology Ph.D. candidate)

A/Prof Kristen Pammer Ph.D.

The Australian National University

Brief Description of the Study

You are being invited to participate in a research study investigating cognitive functions engaged in activities such as driving and the effects of training. Many cognitive functions decline to some degree due to normal ageing; however there is evidence that training may result in significant recovery of these functions. This project is designed to assess the possible transference of training benefits gained over time in specific cognitive functions to more general activities such as driving.

Your Participation in the Study

If you choose to participate in the study you will be asked to attend for two or three sessions at the ANU. In the first session you will firstly complete a small selection of tests to measure your current cognitive abilities. This will assist in matching and comparing your data with your later results. You will then be asked to complete a number of tests on a computer. For example, one of the tasks is to watch letters appear on the screen and to hit a button whenever you see an X; another is to nominate the presence of a coloured shape in the presence of other distracting shapes.

Participation in the first session will take approximately 2 hours.

You will then attend another session at the ANU approximately two weeks after Session 1. At Session 2 you will repeat the computer based tasks completed previously and should you choose to continue with the training component of the study, you will be provided with information that will give you on-line access to some computer activities similar to those completed in sessions one and two. Session 2 will take approximately 45 minutes. You will then be asked to complete the on-line activities each day (if possible) for a period nominated by the experimenter and agreed by you. This period will be a minimum of 14 days and a maximum of 28 days. If you would like, you will be given training on how to access the on-line activities on your computer of choice.

After the completion of the on-line activity period, or after the initial 14 days, you will be asked to return and repeat today's computer tests which will be compared with your initial results. You will also be asked some questions about your views about doing the on-line activities. This session should take approximately 45 minutes.

Participation in this study is voluntary. You may refuse to participate, refuse to answer any questions or withdraw from the study at any time with no effect. You may withdraw at any time, without offering an explanation or reason for your withdrawal.

You have the right to be given all information about your participation in the study and what you will be asked to do. You should only agree to take part if you feel happy that you understand what your participation involves. You do not have to take part in the study if you do not want to.

Please know that you do not waive any legal rights by signing the consent form. Your signature simply indicates an interest in participating in the study. Your personal details (i.e. your name) from this Statement of Informed Consent will in no way be connected to the experimental data, as the consent form and data will be stored separately.

Risks and Benefits of the Study

There are no known risks to your participation in this study. Some of the computer activities may become tedious over time. However, you can stop participating at any time, complete the on-line computer activities as frequently or infrequently as you choose or cease altogether at any time.

There is no direct benefit to your participation in this study. However you may find it interesting and informative. Further, the information you provide will help us to answer some very important questions about brain processing and training.

Confidentiality

All possible steps will be taken to ensure the information you provide is kept confidential. If you choose to participate, the only materials that will contain information that could identify you will be the consent form. These consent forms will be kept in a locked room at The Australian National University, and only the investigators will have access to them. All other materials and data will be given an identification number. These materials will be kept separate from the consent forms to ensure that your confidentiality is protected.

Statement of Privacy.

Completed test forms and test data will be held in accordance with the National Statement on Ethical Conduct in Research Involving Humans. Reports resulting from this data may be presented at conferences and/or submitted for publication in professional journals, however individual participants will not be identifiable, and only group data will be published.

If you have any immediate questions about this study, including your participation, please feel free to address them with the investigator administering today's tests. Alternatively, if in the future you have any questions about the study, the results of the study and/or direction of this research please contact either of the investigators:

Iris Carter
Research School of Psychology
02-6125 5043
Iris.carter@anu.edu.au

A/Prof Kristen Pammer
Research School of Psychology
02-6125 0196
Kristen.Pammer@anu.edu.au.

If you have any concerns about the way the research was conducted please contact the Secretary, Human Research Ethics Committee, Research Office, Chancelry 10B, The Australian National University, ACT, 0200 (02 6125 2900) or human.ethics.officer@anu.edu.au). The ethics protocol for this research is 2012/702.

Thank you for taking the time to read about this research study.

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CONSENT

I,.. give my consent to participate in the Cognitive Training and Driver Capability Study described above on the following basis:

I have had explained to me the aims of this research project, how it will be conducted and my role in it.

I understand the risks involved as described above.

I am cooperating in this project on condition that:

- My participation in the study will be anonymous and individual responses will not be available to anyone.
- The information I provide will be kept confidential.
- Any published reports of this study will preserve my anonymity.

I understand that:

- there is no obligation to take part in this study,
- if I choose not to participate there will be no effect
- I am free to withdraw at any time without penalty

I have been given a copy of the information sheet to keep and may retain a copy of this consent form, signed by me and by the principal researcher if I wish.

______________________	______________________
Signature of participant	Signature of researcher
	Iris Carter
______________________	______________________
Name of participant	Name of researcher
Date	Date

4

Appendix Ib. Demographic Information

Cognitive and Higher Order Sensory Training and Improvements in Driving Capability for Older Adults.

Demographic Information **Participant ID: ____________**

Date of participation: ________________________

Time: ________________________

Sex (circle one): Male Female

Date of birth: ________________________

Country of birth: ________________________

If not Australia, how many years have you lived in Australia? ____________________

Education (in years): ________________________

Occupation: ________________________

(or occupation before retirement if applicable)

Do you wear glasses? ________________________

Have you had your eyesight checked in the last 2 years? ______________________

Are you colour blind? ________________________

Contact Telephone:_______________________________

Appendix IIa. Driving Questionnaire – Personal Driving Experience

Driving Questionnaire 1 **Participant Number**____________

1. At what age did you get your licence / start driving on a regular basis? __________________

2. Are you still driving? If not, when did you stop? ______________________________

3. How many years have you been driving? ____________________________

4. What type of driving have you done?

   For example,

   a. I drove to work and home each day in Canberra and to activities on the weekend.

   b. I lived on a farm and drove to town (200k away) once a month, and drove farm machinery or the farm truck around the property most days.

   c. I was a suburban bus driver / long haul tour bus driver

   ____

   ____

5. Approximately how many klms / hours-a-year were you driving during your working life?

   ____

6. Approximately how many klms / hours-a-year are you driving now?

   ____

7. Have you had a car accident in the last 5 years? If so, were you at fault?

   ____

Appendix IIb. Manchester Driver Behaviour Questionnaire

Driver Behaviour Questionnaire **Participant No:** ____________________

How frequently does this happen to you?	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly all the Time
Underestimate the speed of an oncoming vehicle when overtaking						
Brake too quickly on a slippery road, or steer the wrong way into a skid						
Queuing to turn left onto main road, you pay such close attention to the main stream of traffic that you nearly hit the car in front						
Fail to check rear-view mirror before pulling out, changing lanes, etc.						
Fail to notice pedestrians crossing on turning into a side road						
Miss give way signs and narrowly avoid colliding with traffic having right of way						
On turning left, nearly hit a cyclist who has come up on your inside						
Attempt to overtake someone you had not noticed to be signalling a right turn						
Misread signs and take the wrong turning off a roundabout						
Get into the wrong lane approaching a roundabout or junction						
Forget where you left your car in a car park						
Realize you have no recollection of the road along which you have just been traveling						

Appendix IIb. Manchester Driver Behaviour Questionnaire

Driver Behaviour Questionnaire **Participant No:** ___________________

How frequently does this happen to you?	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly all the Time
Intending to drive to destination A, you suddenly notice that you are on the road to destination B, perhaps because B is your more usual destination						
Switch on one thing, such as the headlights, when you meant to switch on something else, such as the wipers Hit something when reversing that you had not previously seen						
Attempt to drive away from traffic lights in too high a gear						
Disregard the speed limits late at night or early on the morning Become impatient with a slow driver in the outer lane and overtake on the inside						
Cross a junction knowing the traffic lights have already turned against you						
Drive especially close to the car in front as a signal to its driver to go faster or get out of the way						
Have an aversion to a particular class of road user, and indicate your hostility by whatever means you can						
Drive even though you realize that you may be over the legal blood-alcohol limit						

Driver Behaviour Questionnaire **Participant No:** ___________________

How frequently does this happen to you?	Never	Hardly Ever	Occasionally	Quite Often	Frequently	Nearly all the Time
Get involved in unofficial 'races' with other drivers Angered by another driver's behaviour, you give chase with the intention of giving him: her a piece of your mind						

3

Appendix IIc. Perception of Driving Skills and Self-rated Hazard Perception Questionnaire

Driver Questionnaire 2 **Participant Number ______________**

Please put a cross in the box that best represents your hazard perception ability. (1)

Item	Compared to other drivers your age, how skilful are you at...	Much less	Some what less	Slightly less	The same	Slightly more	Some what more	Much more
1	Spotting hazards quickly?							
2	Spotting hazards with enough time to react?							
3	Spotting numerous hazards at a time?							
4	Reacting to more than one potential hazard at a time?							
5	Spotting hazards in heavy traffic?							
6	Spotting hazards in light traffic?							

Please circle the response that best represents your driving experience (2)

Item		Often	Sometimes	Seldom	Never
	When driving in roundabouts how often have you failed to appreciate the nearness to you of other vehicles in the roundabout?	Often	Sometimes	Seldom	Never
	Allowing for the blind-spot in your vehicle, and after looking before pulling out from the kerb, how often does another vehicle suddenly appear in the lane beside you?	Often	Sometimes	Seldom	Never

1

Driver Questionnaire 2 **Participant Number ______________**

	How frequently do you feel uncomfortable when about to change lanes, because you cannot tell how close another vehicle is to you?	Often	Sometimes	Seldom	Never
	When reversing your car do you misjudge the available space?	Often	Sometimes	Seldom	Never
	Whilst driving, do you become anxious when approaching busy roundabouts?	Often	Sometimes	Seldom	Never
	Does the proliferation of advertising signs on the roadside make it difficult to differentiate them from signs giving traffic information?	Often	Sometimes	Seldom	Never
	How often do you misjudge the distance to stop to avoid colliding with another vehicle?	Often	Sometimes	Seldom	Never
	The level of self confidence in your own driving ability is	Low	Moderate	High	Very High
	What level of stress does driving in heavy traffic cause for you?	Very Low	Low	High	Very High
	Judging the speed of oncoming vehicles is:	Extremely difficult	Moderately difficult	Somewhat difficult	Not difficult
	When driving on city and suburban roads, do vehicles in adjacent lanes appear to be encroaching on the lane in which you are driving?	Often	Sometimes	Seldom	Never

(1) White, M. J., Cunningham, L. C. & Titchener, K. (2011).
(2) Conlon, E. & Herkes (2008).

2

Appendix IIIa. Experimental Group – Attention Condition – Instruction Book and 14-Day Diary

attentiondriving.com **Your 4 digit ID number: 1059**

Written instructions for computer based practice tasks.

ATTENTIONDRIVING

Welcome and thank you for participating in this study.

Table of Contents

attentiondriving.com **Your 4 digit ID number: 1059**

Written instructions for computer based practice tasks.

Thank you for your participation.

Following are instructions, additional information, and some explanations for the computer based part of the study. However, if you get stuck, or need help, please do not hesitate to call:

Iris: 0415 832 343

Or 612 55043

The 4 digit id number is the number you enter at the beginning of each computer based practice session. Your number will remain the same throughout this study.

Introduction:

This is a study where we are looking at the effects of practice on the performance of specific, driving related tasks. You will have already completed the first session where you provided some history and driving information about yourself, and you completed some pen and pencil based tasks and some computer based tasks. The next phase of the study is where you do as much practice as you can manage over the next 14 days on the computer based, practice tasks.

Please let me remind you that you are under no obligation to complete this study should you decide you do not wish to continue. There is no penalty for not completing all or some of the study. Should you choose to withdraw from the study you are under no obligation to provide any reason or explanation for your decision.

However, if you are happy to continue with the study, it is quite likely that you will not be able to complete the practice tasks every day. Other obligations and time constraints may prevent you from sitting down and completing the tasks on some days. This is perfectly understandable and expected. We would, however, ask that, if you are happy to give us some brief information about why you could not do the tasks on a missed day so we can add that information to our data collection. The ultimate objective is to develop an on-line practice regime that will transfer to driving skills and confidence and so knowing the nature of things that prevent practice will add to the final design.

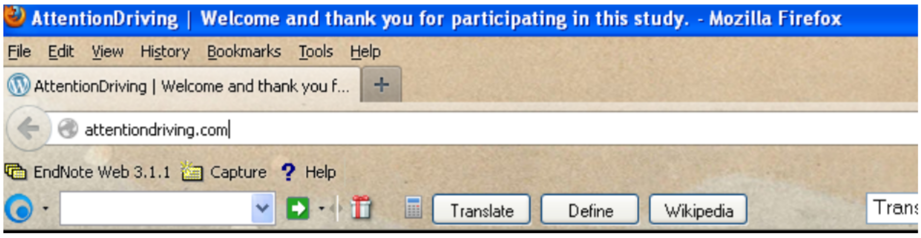
We will also like you to complete a brief practice diary (refer the back of this booklet) which will provide data about best times of day, mood when completing tasks, etc. It would be best if you could complete the diary before you start your practice session and on completion, but if you miss a practice session on any day, please complete the diary as soon as practical.

The rest of this booklet will give you a written version of the instructions and screens you will see as you access and progress through the practice tasks. Once you have done the practice sessions a few times, you may find you no longer need this booklet. If so, don't forget to complete the practice diary each day anyway. Thank you again and I hope you enjoy participating in this study.

attentiondriving.com **Your 4 digit ID number: 1059**

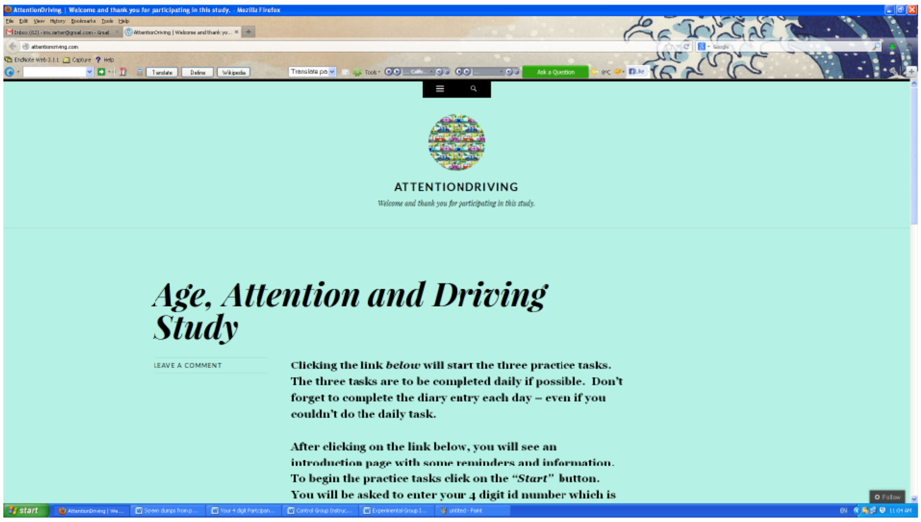
How to access the computer tasks:

Type **attentiondriving.com** into the address line at the top of your browser :



This will bring you to the web page that looks like this:

attentiondriving.com



The wording on the web page under the heading ***Age, Attention and Driving Study*** reads as follows:

Clicking the link *below* will start the three practice tasks. The three tasks are to be completed daily if possible. Don't forget to complete the diary entry each day – even if you couldn't do the daily task.

4

attentiondriving.com **Your 4 digit ID number: 1059**

After clicking on the link below, you will see an introduction page with some reminders and information. To begin the practice tasks click on the *"Start"* button. You will be asked to enter your 4 digit id number which is on the top of your written instruction booklet. You will have to enter this number twice. Once your id number has been verified you will go straight to the first task. Each new task will commence automatically once the previous task has completed.

Each task has an introduction page. If you need a short break, you can delay moving on from the introduction page. However, if you have to stop before you have completed all three tasks, you can press the "Ctrl" key and the "Q" key together and that will end all tasks and the session.

If you need to skip a task and move on to the next you can press the "Ctrl" key and the "B" key and the current task will stop and you will be taken to the beginning of the next task.

Thank you again for your participation.

Cheers

Iris Carter

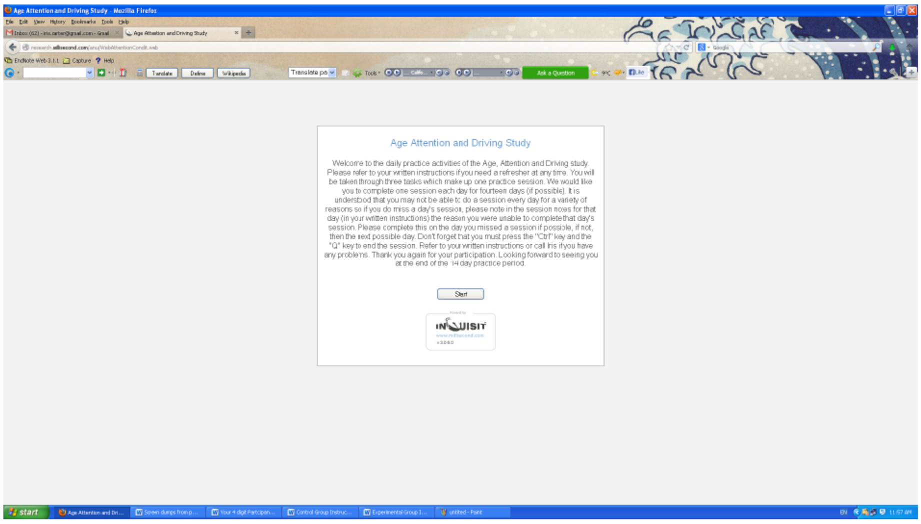
Research School of Psychology

Australian National University

Link to Practice Tasks

If you scroll down the page you will see the link to the tasks (the blue "Link to Practice Tasks" phrase). Mouse click on the link and it will take you to the introduction page for the tasks.

attentiondriving.com **Your 4 digit ID number: 1059**



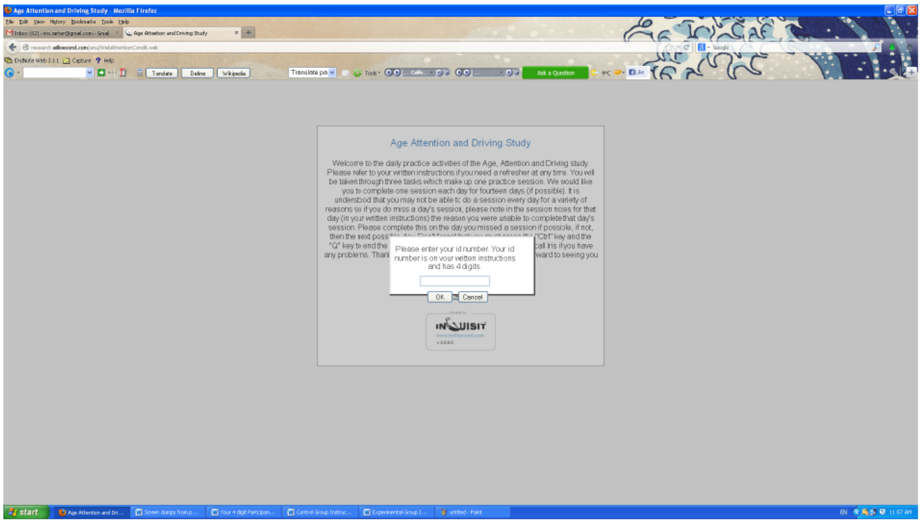
This instruction reads:

Age, Attention and Driving Study

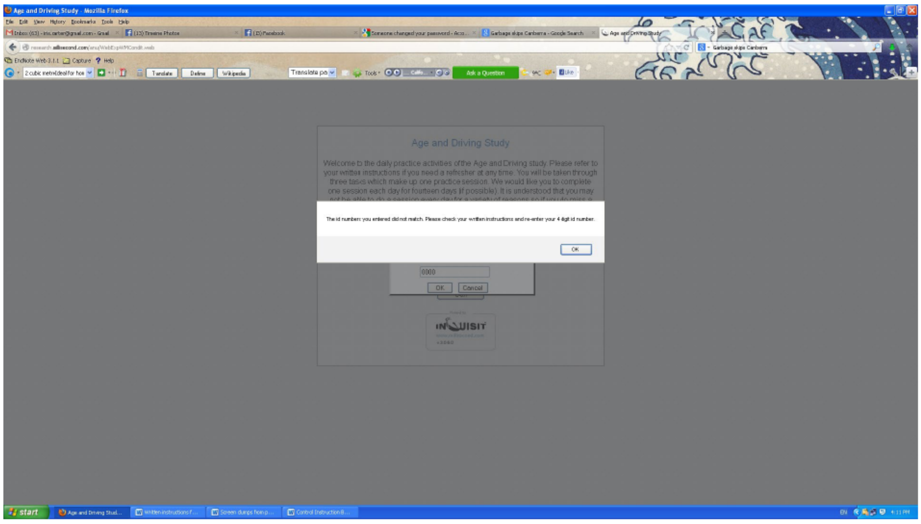
Welcome to the daily practice activities of the Age and Driving study. Please refer to your written instructions if you need a refresher at any time. You will be taken through three tasks which make up one practice session. We would like you to complete one session each day for fourteen days (if possible). It is understood that you may not be able to do a session every day for a variety of reasons so if you do miss a day's session, please note in the session notes for that day (in your written instructions) the reason you were unable to complete that day's session. Please complete this on the day you missed a session if possible, if not, then the next possible day. Don't forget that you must press the "Ctrl" key and the "Q" key to end the session. Refer to your written instructions or call Iris if you have any problems. Thank you again for your participation. Looking forward to seeing you at the end of the 14 day practice period.

When you are ready, click on the "Start" button. A box will come up and ask you to enter your 4 digit id number.

attentiondriving.com **Your 4 digit ID number: 1059**



Click on the empty panel in the box and enter your id number (on the top front cover of this written instruction book). Click "OK" and a second, similar box will come up asking you to verify the number by re-entering it. Click on the empty panel in the box, enter your 4 digit number a second time and click on "OK". This step is included to make sure your id number is entered correctly and we don't get your data mixed up with anyone else's. If the numbers you have entered on the two separate occasions do not match, a message stating: "The id numbers you entered did not match. Please check your written instructions and re-enter your 4 digit id number." (Below is a picture of the screen.)



Click on “OK” and you will be taken back to the first id number box and this process will start again.

Once the id number has been successfully entered, the first task will load. It takes a couple of minutes so don’t worry if it seems to be taking a while, it will get there. ☺

If this is the first time you have accessed this program or if you have changed computers from the one you have run the tasks previously, you will get an information box come up before the first task loads. See the box on the next page for a sample of how the message looks. The message reads:

Application Run – Security Warning

Do you want to run this application?

Name: Inquisit 3.0 Web Edition

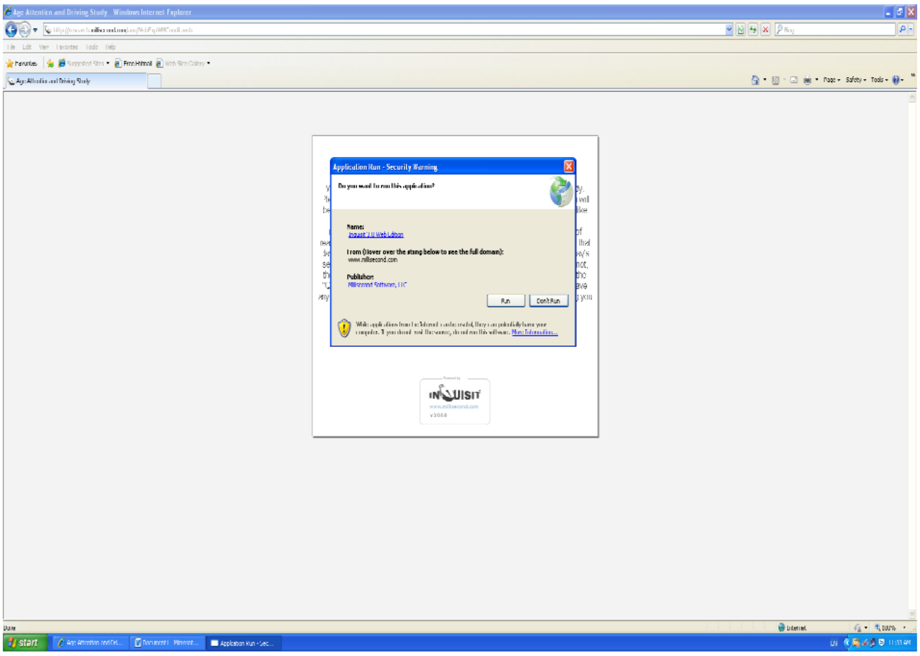
From: www.millisecond.com

Publisher: Millisecond Software, LLC

Run Don’t Run

(See the screen sample on the next page).

attentiondriving.com **Your 4 digit ID number: 1059**



To proceed, mouse click on the Run button which will download the Inquisit program onto your computer. This will take a minute or two.

If you have any problems loading the tasks, or if anything unexpected happens, there are some trouble-shooting tips starting on page 17. If these tips do not sort out your problem, please call Iris on **0415 832 343 or 612 55043.**

The following pages contain the on-screen instructions for each practice task.

attentiondriving.com **Your 4 digit ID number: 1059**

Instructions for the computer based tasks:

Task 1 – Visual Search (Red Square)

The first of the three practice tasks is a search task where you are to look for a red square among varying numbers of red circles and green squares. This is a timed task and your objective is to correctly nominate if a red square is present or not, as quickly as you can. You get feedback at the end of this task so you can monitor any changes in performance as you progress through the 14 day practice period.

You will see an instruction page with the following:

> Thank you for participating in this attention task.
>
> On each trial you will see a number of red circles and green squares. On some trials there will also be a Red Square present.
>
> Your task is to hit the 'p' key if the Red Square is present,
> or the 'a' key if the Red Square is absent as quickly as you can.
>
> Press the spacebar to run through an example.

You will then be presented with two practice examples firstly demonstrating an example with the red square present, and the next demonstrating an example with the red square absent. Firstly you will see the instruction page, then you press the spacebar to continue to the second instruction page and again to see the first example.

> In the following example, the Red Square is PRESENT so you would press the 'p' key as quickly as possible.
>
> Press the 'p' key when you see the Red Square on the next screen.
>
> Press the spacebar to proceed.

After you have pressed the spacebar, you will see a screen with red circles, green squares scattered over the screen and a red square in the bottom right quadrant. Press the p key when you see the red square. The screen will stay until you press the 'p' key. Then the next instruction page will be presented.

> In the following example, the Red Square is ABSENT so you would press the 'a' key as quickly as possible.
>
> Press the 'a' key after searching for the Red Square among the red circles.
>
> Press the spacebar to proceed.

Again, once you have pressed the spacebar, you will see a screen with red circles and green squares but this time there is no red square. Search for a red square and once you are satisfied it is not there; press the ‘a’ key to proceed to the next screen.

The final reminder screen will present after the red square absent example:

> Remember to hit the 'a' key if the Red Square is ABSENT
>
> Or to hit the 'p' key if the Red Square is PRESENT
>
> Press the space bar to begin the task.

Once you press the spacebar you will be presented with 72 trials and takes about 2 minutes in total. Don’t forget to respond as quickly as you can but your goal is for accuracy as well as speed and both are equally important. There is no break between trials so the next trial is presented as soon as you respond. However, once complete, if you wish you can take a short break before progressing to the next task. When the screen presents the following message you can delay pressing the space bar until you are ready to go on to the next task.

> Thank you for participating. Please press the space bar to move to the next task.

Task 2 – Continuous Performance

This task is all about maintaining your attention over a long period particularly when things get tedious and boring. This task presents a stream of letters, one after the other. Your jobis to press the spacebar, as quickly as you can, when you see an 'A' followed by an 'X'. There may be 'A's and 'X's but you are only to press the spacebar if the 'X' follows an 'A'. This task is very long – it runs for a minimum of 9 ½ minutes without stopping so it is important you are able to sit at the task for that period. (If not, refer to the note at the end of this section.) Your response is also timed so it is important to press the spacebar as quickly as you can as soon as you see an 'A' followed by an 'X'. However, do not press the spacebar for any other letter or letter combination.

After pressing the spacebar following Task 1, you will see the instruction page for the Continuous Performance Task:

> Welcome to the Continuous Performance Test.
>
> When the test starts, you will see letters appearing one at a time.
>
> Your task is to press the spacebar key every time you see an X, but only when it follows directly after the letter A.
>
> So you only press the spacebar when you see an X that follows an A.
>
> If any other letter appears on the screen, simply wait for the next letter to appear without pressing any keys.
>
> Whenever you see the letter A, get set; if an X comes right after it, press the spacebar.
>
> Press the spacebar now to continue.

Once you have pressed the spacebar the task begins and does not stop for at least 9 ½ minutes. When this task is done the following will appear on the screen:

> This task is complete.
> Thank you for your participation.
>
> Press the space bar to continue.

I suggest you have a stretch and a break before you begin the next task.

attentiondriving.com **Your 4 digit ID number: 1059**

Task 3 – Divided Attention

This task is about spreading your attention outside your direct eye gaze. Although humans can see and attend best in their direct line of sight, we are also able to discriminate visual information in our periphery. We also process a lot of visual information subconsciously – that is, without being aware we are doing it. Because of these abilities, you may be surprised at how well you do, despite this task being quite challenging. The key to this task is to try to relax while you are doing it and to make sure you are sitting with your eyes aligned with the centre of the screen.

Your goal in this task is to nominate if a target is present or absent. As in Task 1, you will use the 'p' and 'a' keys; the 'p' key if the target is present, and the 'a' key if the target is absent. However, in this task, the presentation is very fast and you do not have time to move your eyes to search for the target. In fact you will perform better if you can keep your eyes fixed on the star in the middle of the screen throughout the task. The fixation star also provides a clue as to where to direct your attention (but not your eyes). One of the arms of the star will turn white, effectively pointing to the position where the target will be. *If* the target is present, it will always be where the arm is pointing.

Another important point is that the presentation on the screen is very brief and you will often think you didn't see enough to answer if the target was absent or present. If this happens then go with your best guess. This is where the subconscious processing is going on – your guess will often be correct because you have processed the visual information subconsciously but not to the extent that you have any certainty or confidence about your answer. This task also becomes easier when you have done it a few times.

This is a timed test and your objective is to answer as quickly and correctly as you can. It begins with a series of instruction screens, a comparison of the target against a non-target, followed by two examples; one where the target is present, the other where the target is absent. There are 36 trials and completing this task will take around 2 minutes. You receive feedback at the end of the task and you can use this to monitor any changes in your performance during the 14 day practice period.

After pressing the spacebar after Task 2, you will see the initial instruction page for this Divided Attention task:

> Thank you for participating in this attention task.
>
> Your challenge is to determine if the target is present or absent in each trial.

> Both the target and distractors in each trial are striped ovals but the target has more stripes.
>
> The fixation star at the centre of the screen has a white arm that will point to the target if it is present, and will point to a random location if the target is absent.
>
> Press the spacebar to see an example.

When you press the spacebar a screen will appear with two vertically striped ovals. The oval with more stripes is the target. The target is on the left in the first screen and a non-target is on the right. The screen will remain for a short time, then switch so the target is on the right and the non-target oval is on the left. The next screen takes you to a preview of the task.

> The following is a preview of the task; however the preview is much slower than the actual task.
> You will see the fixation star at the centre of the screen with its pointing arm, followed by a circle of 8 ovals. This will be followed by a response prompt which is a black X with a white + over the top.
>
> The target is PRESENT in this example - the arm on the fixation cross is pointing to the target.
>
> You would press the 'p' key as quickly as possible.

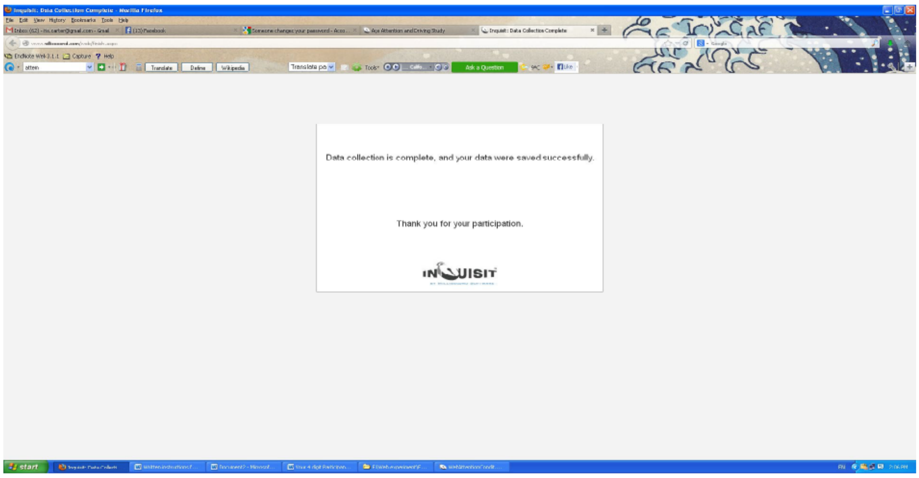
After you press the spacebar the screen will show a circle of striped ovals with the white arm on the fixation star pointing to the target in the lower right quadrant. The screen will only be visible for a few seconds but will give you enough time to comfortably follow the pointing arm to the target which is in the lower right quadrant. Another screen appears which instructs you to press the 'p' key because the target was present. When you press the 'p' key a preview without a target is presented:

> The target is ABSENT in the following example - the arm on the fixation cross is pointing to an oval that is the same as all the others.
>
> You would press the 'a' key as quickly as possible.

This time, all the ovals on the screen are non-targets and they all look the same. Again, the screen will only be available for a few seconds but you should see that the arm on the fixation cross is pointing to the same place as the previous example, but this time the oval in that place is a non- target as it has the same number of stripes as all the other ovals on the page. You are not expected to count them, just recognise that all the ovals on this page are the same. The next screen confirms that you would press the 'a' key as the target was absent. One more instruction screen appears after you press the 'a' key:

> The experimental task that follows is much faster than the previous examples and you may think you have not seen enough to respond.
>
> However, you often see things without any conscious awareness and what feels like a guess is often a correct subconscious response. So give it your best guess!
>
> Make sure your head is square with the screen, keep your eyes on the fixation star (you won't have time to move your eyes) and try to expand your "attention" in the direction of the pointing arm to identify if the target is present or not.
>
> Don't forget to hit the 'p' key if the target is present, or the 'a' key if the target is absent - as quickly as you can.
>
> Press the spacebar to begin.

Once this task is completed the practice session is done. Press the Ctrl key and the Q key together to exit. You will see the following screen which confirms your data has been collected successfully:



This message reads:

Data collection is complete, and your data were saved successfully. Thank you for your participation.

attentiondriving.com **Your 4 digit ID number: 1059**

You can now close the web page by clicking on the cross in the top, right-hand corner of the screen.

Notes and Hints

If you have to leave the computer before all three tasks have been completed:

Sometimes things happen that interrupt your practice session and you may not be able to complete all tasks. If you can, complete the task you are doing but if you can't do this, you can still end the session in the middle of a task.

> To end the session at any time: press the **Ctrl key** and the **Q key** at the same time.

This is the same thing you do once you have completed all tasks and you are ready to end your session. The screen (previous page) noting the collection of data and thanking you for your participation will appear and you can close the web page. It is important you end the session by using the Ctrl Q command otherwise the session remains open and may corrupt any data that you have contributed during this session.

If you have to skip an individual task:

There may be some reason you wish or need to end a particular task but you are able to continue with the remaining task(s). You can jump directly to the next task even if you have already started the task you wish to skip.

> To skip to the next task at any time: press the **Ctrl key** and the **B key** at the same time.

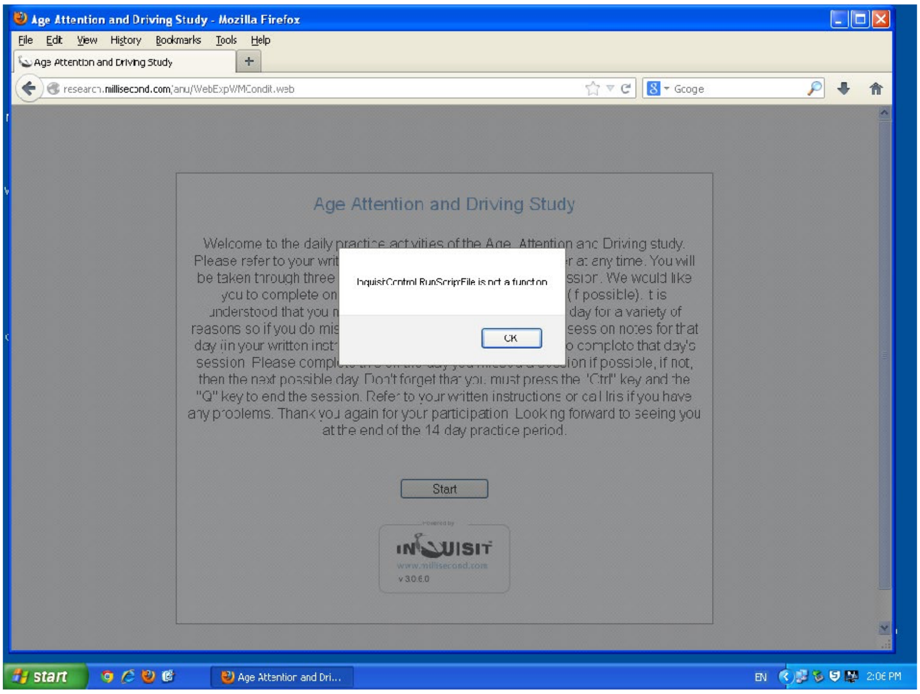
This way you can opt out of a particular task but continue with the other tasks. An example is if the telephone rings and rather than leave the task run without anyone responding you could press the Ctrl and B keys which would move you to the beginning of the next task. You could take your call and return to the remaining tasks when you are ready.

attentiondriving.com **Your 4 digit ID number: 1059**

Troubleshooting!

The following are computer type things that may happen and prevent you from starting or completing your daily practice tasks. These events have been investigated and some solutions or alternatives provided. You may encounter something not on this list – if so; I would love to hear about it as soon as practical for you so I can try to address the problem.

1. You may have updated to the latest version of Firefox web browser and you get the following message after you have entered your id number:



The message reads: InquisitControl.RunScriptFile is not a function.

This error occurs with the latest upgrade of Firefox but older versions do not have this problem. If you encounter this problem, switch to using Internet Explorer as your browser.

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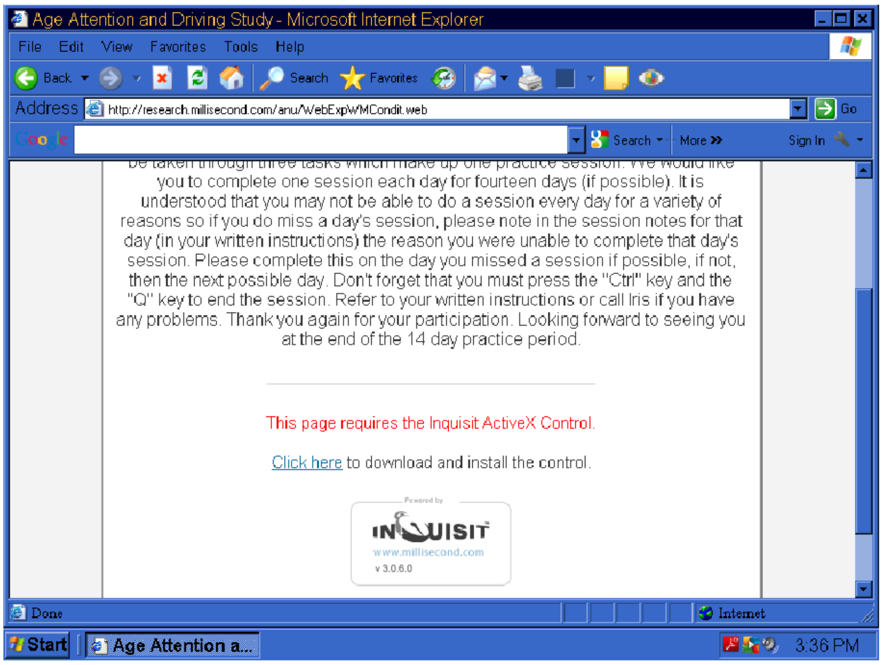
attentiondriving.com **Your 4 digit ID number: 1059**

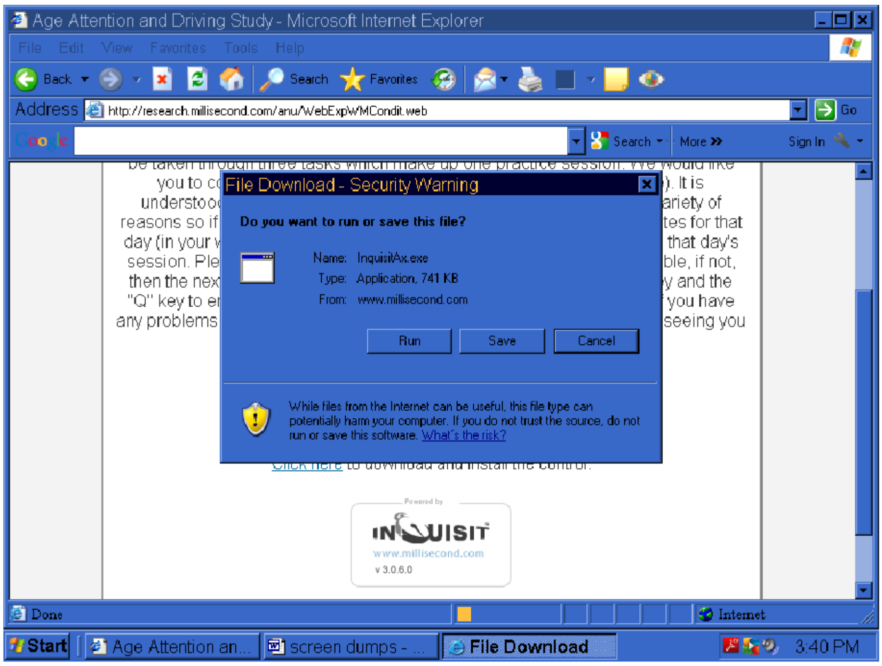
This is the Internet Explorer icon. Click on it to open up this browser rather than using Firefox.

2. When you first click on the "Start" button in the "Age, Attention and Driving Study" page a message may appear:



The message reads: This page requires the Inquisit ActiveX Control.

This is a similar message to the one that requests you download the Inquisit Web program mentioned earlier in the instructions and is also about loading the program onto your computer. Click on the blue "Click here" and the following message will appear:



This message reads:

File Download – Security Warning

Do you want to run or save this file?

Name: InquisitAx.exe

Type: Application, 741 KB

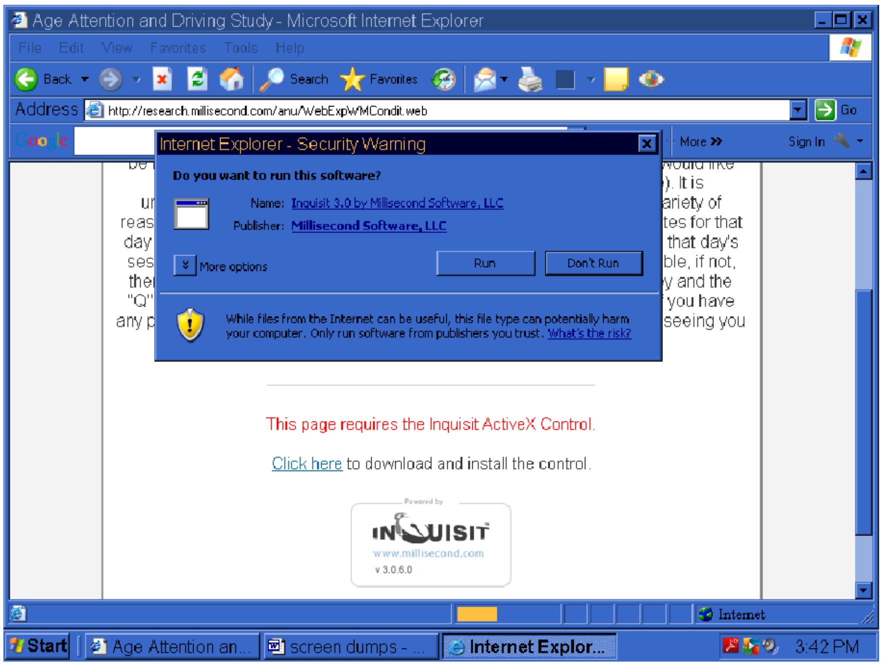
From www.millisecond.com

Run Save Cancel

! While files from the Internet can be useful, this file type can potentially harm your computer. If you do not trust the source, do not run or save this software. What's the risk?

In order to run the practice tasks, the computer program needs to load some program files onto your computer. Therefore, if you click on Run, loading the files from the internet will commence. Once all the required files have been downloaded the following message box appears:

attentiondriving.com Your 4 digit ID number: **1059**



This message reads:

Internet Explorer – Security Warning

Do you want to run this software?

Name: Inquisit 3.0 byMillisecond Software, LLC

Publisher: Millisecond Software, LLC

More options Run Don't Run

! While files from the Internet can be useful, this file type can potentially harm your computer. Only run software from publishers you trust. What's the risk?

Running the program enables the practice tasks to run on your computer, so click on Run. The following message box will appear:

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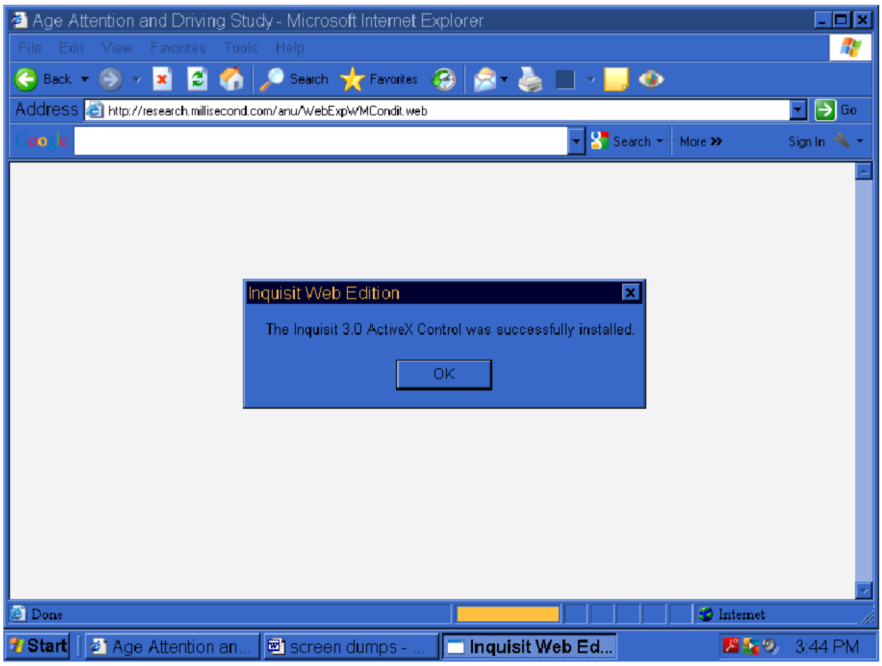
attentiondriving.com **Your 4 digit ID number: 1059**



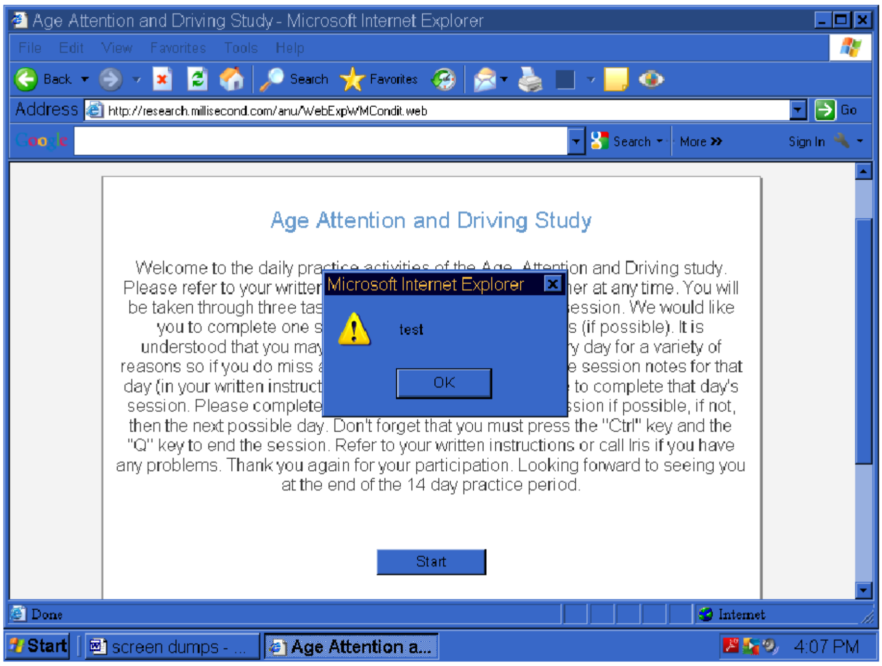
This message reads:

Inquisit Web Edition
The Inquisit 3.0 ActiveX Control was successfully installed.
OK

This message is to confirm the successful loading of the required program files. The purpose of clicking the OK button is to resume starting the practice tasks.

On some computers the following message will appear:

attentiondriving.com **Your 4 digit ID number: 1059**



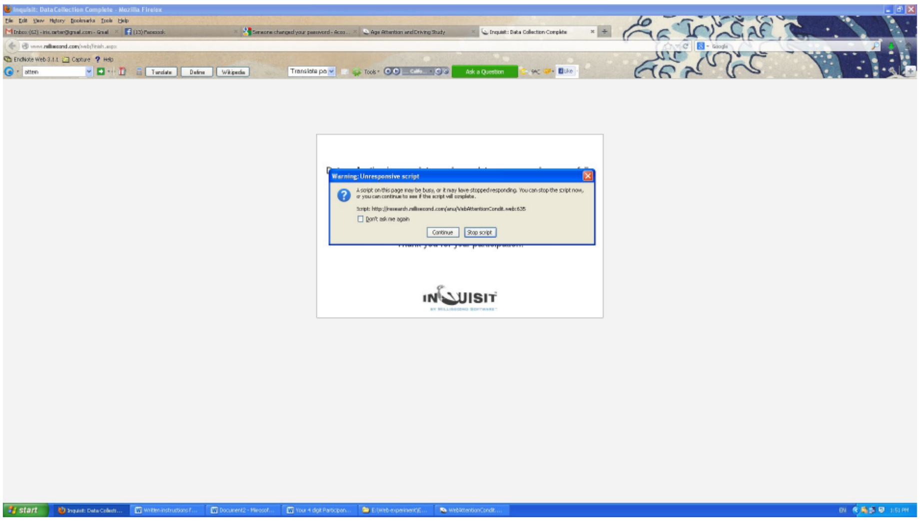
The message reads:

Microsoft Internet Explorer
! test
OK

Click on the OK box to resume.

attentiondriving.com **Your 4 digit ID number: 1059**

3. You have entered your 4 digit id number and the OK key is unresponsive until the following message pops up:



The message reads:

Warning: Unresponsive Script

A script on this page may be busy, or it may have stopped responding. You can stop the script now, or you can continue to see if the script will complete.

Script: http://research.millisecond.com/anu/WebAttentionCondit.web:635

▯ Don't ask me again

Continue Stop script

If you see this screen, click on the *Continue* button and wait a minute or two to see if the program starts. If the program does not start click on the *Stop script* button and go back to the *AttentionDriving.com* web site and start again.

attentiondriving.com Your 4 digit ID number: 1044

14 Day Session Diary

How to complete your daily diary

The following pages are your 14 day session diary which gives you the opportunity to provide some information about how you are feeling. Your mood at the time of doing the practice tasks may affect how you perform. Also, events that occur during the day may also affect your willingness and ability to do the practice. The diary provides you with an opportunity to share your thoughts and feelings when you first sit down to do the practice as well as when you are done.

The suggested "moods" are not a complete list, nor are they suggestive of any mood we are expecting. They are just some ideas. If one of the suggestions fits how you are feeling, circle it. If none fit, write in a better description on the line below the list of mood words.

Also, if you do not get to the practice on any day, if you are happy to give us some brief information about why you could not do the tasks on a missed day we can add that information to our data collection. It may have been due to a busy day, visitors, or maybe just not in the mood. Whatever the reason, we would really appreciate - if you are happy to share.

The ultimate objective is to develop an on-line practice regime that will transfer to driving skills and confidence and so knowing the nature of things that prevent practice will add to the final design.

So, if you didn't get to the practice, and you are happy to share, jot down a line or two in the "Any other comments" section.

attentiondriving.com **Your 4 digit ID number: 1044**

Day 1

Day of week (eg, Monday): Thursday

Date &Time: 23/01/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

excited, anxious

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm, relaxed

Any other comments?

Download went smoothly and instruction were clear for the rest of the practice session

25

attentiondriving.com Your 4 digit ID number: **1044**

Day 2

Day of week (eg, Monday): Friday

Date &Time: 24/01/2014 7am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

cheerful, calm

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

cheerful, relaxed

Any other comments?

I'd had a better than usual nights sleep before this session

26

attentiondriving.com **Your 4 digit ID number: 1044**

Day 3

Day of week (eg, Monday): Saturday

Date &Time: 25/01/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy, relaxed

Any other comments?

Pleased to get 100% correct on test 3!

27

attentiondriving.com   **Your 4 digit ID number: 1044**

Day 4

Day of week (eg, Monday): Sunday

Date &Time: 26/1/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy

Any other comments?

Good to see I'm getting faster on task 3

28

attentiondriving.com Your 4 digit ID number: **1044**

Day 5

Day of week (eg, Monday): Monday

Date &Time: 27/01/2014 7am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

relaxed

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

irritated.

Any other comments?

Results on tests 1 and 3 were less accurate and slower today – disappointing!

29

attentiondriving.com Your 4 digit ID number: 1044

Day 6

Day of week (eg, Monday): Tuesday

Date &Time: 28/01/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Any other comments?

30

attentiondriving.com Your 4 digit ID number: **1044**

Day 7

Day of week (eg, Monday): Wednesday

Date &Time: 29/01/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

restless

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy, relaxed

Any other comments?

Pleased to see my response times on tests 1 and 3 were "personal bests" and the accuracy had stayed up quite well. Being restless seems good!

31

attentiondriving.com Your 4 digit ID number: **1044**

Day 8

Day of week (eg, Monday): Thursday

Date &Time: 30/01/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

cheerful

Any other comments?

Pleased to get 100% on test 3. I haven't done that for a few days.

32

attentiondriving.com Your 4 digit ID number: 1044

Day 9

Day of week (eg, Monday): Friday

Date &Time: 31/01/2014 9pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

tired, happy

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Any other comments?

Done at end of a tiring day. Results were surprisingly good on tests 1 + 3 but I think I did not do very well on test 2.

33

attentiondriving.com Your 4 digit ID number: 1044

Day 10

Day of week (eg, Monday): Saturday

Date &Time: 1/02/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

relaxed

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

cheerful

Any other comments?

Pleased to be getting 100%'s on test 3 (three in a row) and getter faster at it.

34

attentiondriving.com

Your 4 digit ID number: 1044

Day 11

Day of week (eg, Monday): Sunday

Date &Time: 2/02/2014 7am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

annoyed

Any other comments?

Disappointed with my slower reaction times today on tests 1 and 3.

35

attentiondriving.com

Your 4 digit ID number: 1044

Day 12

Day of week (eg, Monday): Monday

Date &Time: 3/02/2014 5am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

lethargic, melancholy

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Any other comments?

Pleased to get good results given the very early time of day (5am!)

36

attentiondriving.com

Your 4 digit ID number: 1044

Day 13

Day of week (eg, Monday): Tuesday

Date &Time: 4/02/2014 6am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

calm

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

happy

Any other comments?

Still haven't got 100% on test 1 – only one day left to crack it!

attentiondriving.com Your 4 digit ID number: **1044**

Day 14

Day of week (eg, Monday): Wednesday

Date &Time: 5/02/2014 7am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

relaxed, happy

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

relaxed, happy

Any other comments?

Had a really good sleep last night but results were not significantly better. They were still good enough to keep me relaxed and happy!

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Appendix IIIb. Control Group – Working Memory Condition – Instruction Book and 14-Day Diary

agedriving.com **Your 4 digit ID number: 2060**

Written instructions for computer based practice tasks.

AGEDRIVING

Welcome and thank you for participating in this study.

Table of Contents

agedriving.com **Your 4 digit ID number: 2060**

Written instructions for computer based practice tasks.

Thank you for your participation.

Following are instructions, additional information, and some explanations for the computer based part of the study. However, if you get stuck, or need help, please do not hesitate to call:

Iris: **0415 832 343**

Or **612 55043**

The 4 digit ID number is the number you enter at the beginning of each computer based practice session. Your number will remain the same throughout this study.

Introduction:

This is a study where we are looking at the effects of practice on the performance of specific, driving related tasks. You will have already completed the first session where you provided some history and driving information about yourself, and you completed some pen and pencil based tasks and some computer based tasks. The next phase of the study is where you do as much practice as you can manage over the next 14 days on the computer based, practice tasks.

Please let me remind you that you are under no obligation to complete this study should you decide you do not wish to continue. There is no penalty for not completing all of the study. Should you choose to withdraw from the study you are under no obligation to provide any reason or explanation for your decision.

However, if you are happy to continue with the study, it is quite likely that you will not be able to complete the practice tasks every day. Other obligations and time constraints may prevent you from sitting down and completing the tasks on some days. This is perfectly understandable and expected. We would, however, ask that, if you are happy to give us some brief information about why you could not do the tasks on a missed day, so we can add that information to our data collection. The ultimate objective is to develop an on-line practice regime that will transfer to driving skills and confidence and so knowing the nature of things that prevent practice will add to the final design.

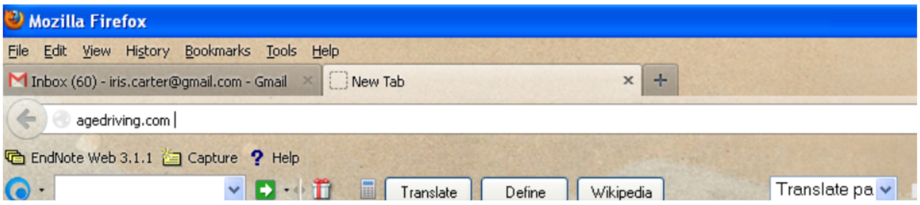
We will also like you to complete a brief practice diary (refer the back of this booklet) which will provide data about best times of day, mood when completing tasks, etc. It would be best if you could complete the diary before you start your practice session, but if you do not do a practice session on any day, please complete the diary as soon as practical.

The rest of this booklet will give you a written version of the instructions and screens you will see as you access and progress through the practice tasks. Once you have done the practice sessions a few times, you may find you no longer need this booklet. If so, don't forget to complete the practice diary each day anyway. Thank you again and I hope you enjoy participating in this study.

agedriving.com **Your 4 digit ID number: 2060**

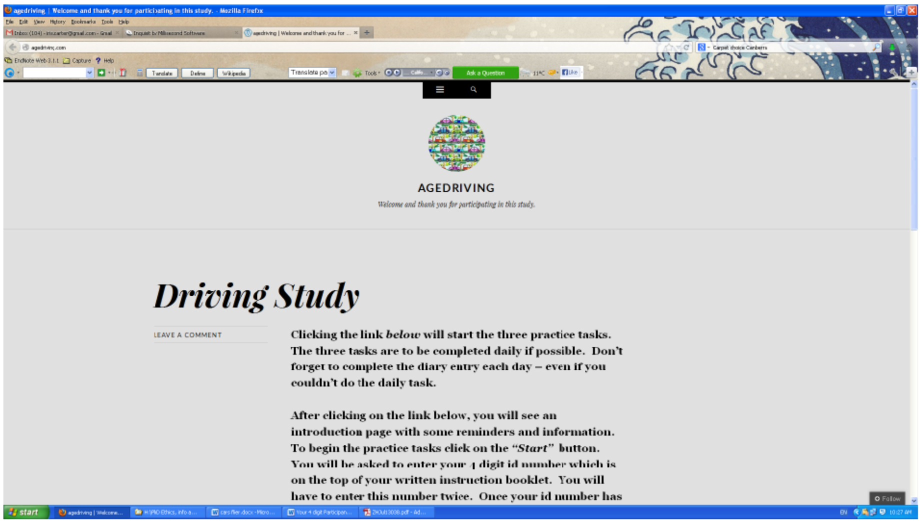
How to access the computer tasks:

1. Type **agedriving.com** into the address line at the top of your browser:



This will bring you to the web page that looks like this:

agedriving.com



The wording on the web page under the heading ***Driving Study*** reads as follows:

Clicking the link *below* will start the three practice tasks. The three tasks are to be completed daily if possible. Don't forget to complete the diary entry each day – even if you couldn't do the daily task.

agedriving.com **Your 4 digit ID number: 2060**

After clicking on the link below, you will see an introduction page with some reminders and information. To begin the practice tasks click on the *"Start"* button. You will be asked to enter your 4 digit ID number which is on the top of your written instruction booklet. You will have to enter this number twice. Once your ID number has been verified you will go straight to the first task. Each new task will commence automatically once the previous task has completed.

Each task has an introduction page. If you need a short break, you can delay moving on from the introduction page. However, if you have to stop the session before you have completed all three tasks, you can end the session by holding down the "Ctrl" key and pressing the "Q" key at the same time.

If you need to skip a task and move on to the next you can press and hold down the "Ctrl" key and press the "B" key and the current task will stop and you will be taken to the beginning of the next task.

Thank you again for your participation.

Cheers

Iris Carter

Research School of Psychology

Australian National University

Link to Practice Tasks

2. If you scroll down the page you will see the link to the tasks (the red 'Link to Practice Tasks' that looks like the above example). Use your Mouse to click on the link and it will take you to the introduction page for the tasks.

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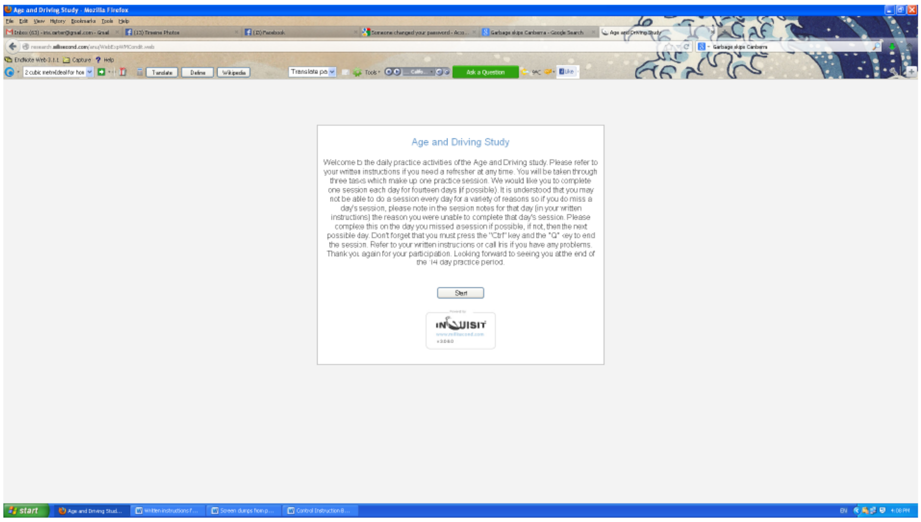
agedriving.com **Your 4 digit ID number: 2060**



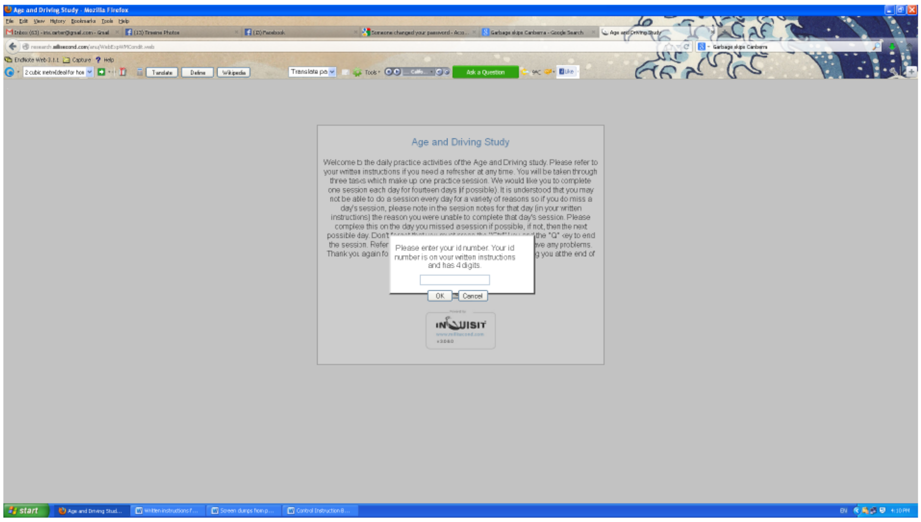
This is the introduction page and the instruction reads:

Age and Driving Study

Welcome to the daily practice activities of the Age and Driving study. Please refer to your written instructions if you need a refresher at any time. You will be taken through three tasks which make up one practice session. We would like you to complete one session each day for fourteen days (if possible). It is understood that you may not be able to do a session every day for a variety of reasons so if you do miss a day's session, in the session notes for that day (in your written instructions) please note the reason you were unable to complete that day's session. Please complete this on the day you missed a session if possible, if not, then the next possible day. Don't forget that you must press the "Ctrl" key and the "Q" key to end the session. Refer to your written instructions or call Iris if you have any problems. Thank you again for your participation. Looking forward to seeing you at the end of the 14 day practice period.

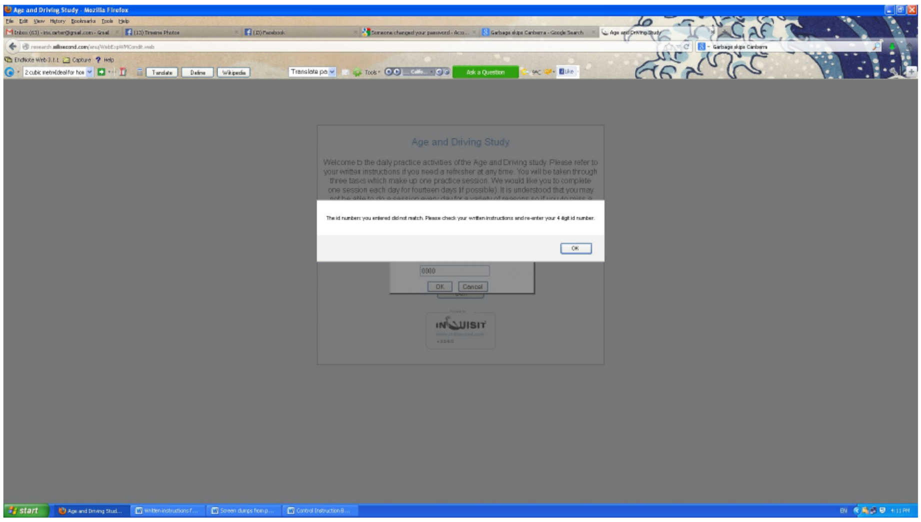
3. **When you are ready, click on the "Start" button which is directly below the above information. A box will come up and ask you to enter your 4 digit ID number.**

agedriving.com **Your 4 digit ID number: 2060**



4. Click on the empty panel in the box and enter your ID number (the number on the top front page of this written instruction book). Click "OK" and a second, similar box will come up asking you to verify the number by re-entering it. Click on the empty panel in the box, enter your 4 digit number a second time and click on "OK". This step is included to make sure your ID number is entered correctly and we don't get your data mixed up with anyone else's. If the numbers you have entered on the two separate occasions do not match, a message stating: "The ID numbers you entered did not match. Please check your written instructions and re-enter your 4 digit ID number." (Following is a picture of the screen message if the two ID numbers do not match.)

agedriving.com **Your 4 digit ID number: 2060**



If this happens, click on "OK" and you will be taken back to the first ID number box and this process will start again.

Once the ID number has been successfully entered, the first task will load. It takes a couple of minutes so don't worry if it seems to be taking a while, it will get there. ☺

If this is the first time you have accessed this program or if you have changed computers from the one you have run the tasks previously, you will get an information box come up before the first task loads. See the box on the next page for a sample of how the message looks. The message reads:

Application Run – Security Warning

Do you want to run this application?

Name:

Inquisit 3.0 Web Edition

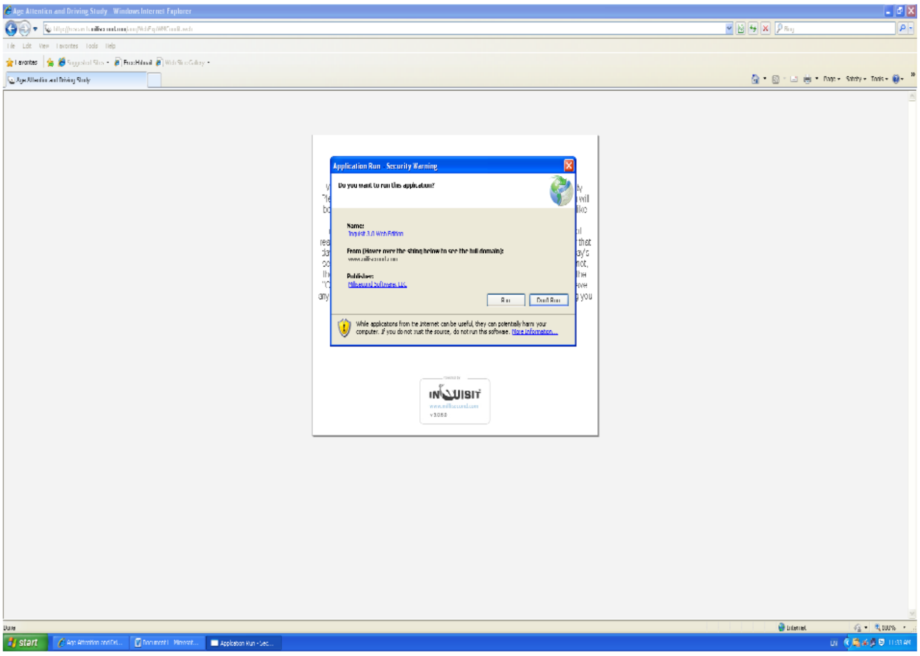
From: www.millisecond.com

Publisher: Millisecond Software, LLC

Run Don't Run

(See the screen sample on the next page).

agedriving.com **Your 4 digit ID number: 2060**



To proceed, use your mouse to click on the Run button which will download the Inquisit program onto your computer. This will take a minute or two.

If you have any problems loading the tasks, or if anything unexpected happens, there are some trouble-shooting tips starting on page 17. If these tips do not sort out your problem, please call Iris on **0415 832 343 or 612 55043.**

The following pages contain the on-screen instructions for each practice task.

agedriving.com Your 4 digit ID number: 2060

Instructions for the computer based tasks:

Task 1 – Card Game

The first of the three tasks is a card game. This game is known as *Pontoon, Twenty-one,* or *Black Jack* and there may be other names. It takes a few seconds to play each hand so this task will not take long. You can decide how many hands you would like to play, but I would suggest around 10. It is basically a game of chance so there is no way you can work on improving your score beyond making decisions that take you close enough to the target score without going over 21. However, your objective is to use the available information to make the best decision so you must think and concentrate. This is not a timed task so you have time to think before your decision.

When driving, you often make many decisions with limited available information

You will see 3 instruction pages before the game begins. The instructions you receive are replicated below:

First page of instructions:

You are playing against the dealer who is also trying to reach a total card value at or below 21.
To make it easier to keep up with the total card value, the total numeric card value of all cards dealt to you is displayed above your first card. The total value of the dealers face-up cards is displayed above the dealer's first card.
Your hand is played out first then the dealer's hand is played.
Press the space bar to continue.

Second page of instructions:

To play the game you are firstly dealt 2 cards face-up and the dealer is dealt one card face-up and another face-down.
After you have looked at your cards you can choose to either "hit" or "stand"
"Hit" means to request another card from the dealer and you press the "H" key.

"Stand" means you do not wish to add another card so you press the "S" key. This means you are ready for the dealer to try to get closer to the card value of 21 without going over 21.
The player who ends up closest to 21, without exceeding 21, wins the hand.

Third page of instructions

If the total value of all cards dealt to you exceeds 21 the dealer wins. If the total value that the dealer draws goes over 21 you win.
If you and the dealer have equal value cards and the dealer does not wish to draw another card it is called a "push" and is deemed the dealer wins.

To play another round of Black Jack, press the "N" key at the end of each game.
To finish playing Black Jack and move on to the next task, press the "Q" key after a game has ended.

press the space bar to begin the game.

This game requires a number of different key presses to play.

The ***spacebar*** moves you from one instruction screen to the next and starts the first game.

The ***H*** key is the one you use to request another card – H stands for Hit (and there is a sign that says HIT under the dealt cards for a reminder).

The ***S*** key is the one you use if you do not want another card but would like to stay with your current cards. S stands for Stand (and there is a sign that says STAND under the dealt cards as a reminder).

At the end of each game, you are asked if you would like to play again or quit.

The ***N*** key is the one to use if you would like to play again (stands for New Game).

The ***Q*** key (stands for Quit) is the key to use if you would like to finish your card session and move onto the next task.

agedriving.com **Your 4 digit ID number: 2060**

Task 2 – Digit Span

The second of the tasks is a working memory task. When driving, you use your working memory constantly to concurrently track things like other vehicle locations, directions to your destination, the speed limit, etc.

The program takes you through two versions of the task; Digit Span Forward and Digit Span Backward. The objective is to correctly recall and type in a string of numbers in the correct order. This task can be very challenging and, as a result, you may come up with some strategies to help you remember the strings of numbers. All strategies, except writing the numbers down ☺, are fine and are likely to be good for your memory. There are 14 trials in each category (forward and backward) so this task can be quite long. Feel free to take a short break between each category if you need to. This task is not timed so although the numbers are displayed for a limited time, you have as much time as you need to respond.

Digit Span gives you feedback once you have completed each of the versions of the task. You can use this if you want to monitor any changes in your performance over the 14 day practice period.

Digit Span Forward is the first task. You will see a number of screens with explanations of the task and instructions as follows:

Following are the introductory screens for Digit Span Forward:

> The following procedure is used to practice the number of digits you can recall. This task is called DIGIT SPAN and it is a measure of working memory.
> The DIGIT SPAN is the maximum number of digits that are correctly recalled after seeing a series of digits.
> The DIGIT SPAN can be assessed for FORWARD recall (= order presented) and for BACKWARD recall (=reversed order).
>
> EXAMPLE:
> (digits presented) ONE SEVEN TWO FOUR NINE
>
> FORWARD RECALL (= in order presented): 17249
> BACKWARD RECALL (= reversed order): 94271

In order to familiarize you with this procedure, you will be given a short practice before starting the actual assessment.
Please, continue when you are ready. (Press the spacebar to proceed)

The following practice is to familiarise you with the FORWARD assessment.
(1) You will first see a red circle in the middle of the screen.
(2) Once the circle disappears, you will see a sequence of digits from 1-9.
(3) Another red circle signals the end of the digit sequence.
(4) A text box is presented in the middle of the screen:
Please type in the digit sequence you saw in THE ORDER it was presented, e.g. if you saw (three, six, two) type 362 into the text box

NO data will be recorded during the practice.
Please, continue when you are ready.

Following are the introductory screens for Digit Span Backward:

The following practice is to familiarize you with the BACKWARD assessment:
(1) You will first see a red circle in the middle of the screen.
(2) Once the circle disappears, you will see a sequence of digits from 1-9.
(3) Another red circle signals the end of the digit sequence.
(4) A text box is presented in the middle of the screen:
Please type in the digit sequence you have seen in the REVERSED order it was presented, e.g. if you saw (three, six, two) type 263 into the textbox

NO data will be recorded during the practice.
Please, continue when you are ready.

After the practice, you move to the actual task.

This task uses the following key presses:

Spacebar to move to the next instruction screen.

Number keys to enter your answer after the presentation of numbers. Note you can use keys on a numeric key pad if you have one, or you can use the numbers along the top of the alphabetical keyboard if you prefer.

After you enter your answer, you use your mouse to "click" on the box that says **NEXT** which will take you to the next set of numbers.

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Task 3 – Dot Estimation

The Dot Estimation task is an exercise in estimation using limited visual information. Your task is to enter your best guess of how many dots are present after a brief viewing. The presentation duration is too short to allow you to count. This task is easier if you try to relax and give your best guess – people are actually very good at guessing. There is no direct feedback after this task but you can ask for feedback on your performance at your return visit to ANU.

Following are the introductory screens for Dot Estimation Task:

> Welcome to the Dot Estimation Task.
>
> You will see a random pattern of dots flashing on the screen for a short amount time. After each pattern, we will ask you to estimate how many dots you just saw on the screen.
>
> Please try to estimate the number of dots as accurately as possible. Do not try to count the dots, they will disappear too quickly.
>
> Enter your estimation into the box provided and press the 'Ctrl' key and the 'Enter' key together to move to the next screen.
>
> At the end of the task your estimations will be added to the data file but you will not receive feedback until you return to the experimenter for the final session.

This task uses the following key presses:

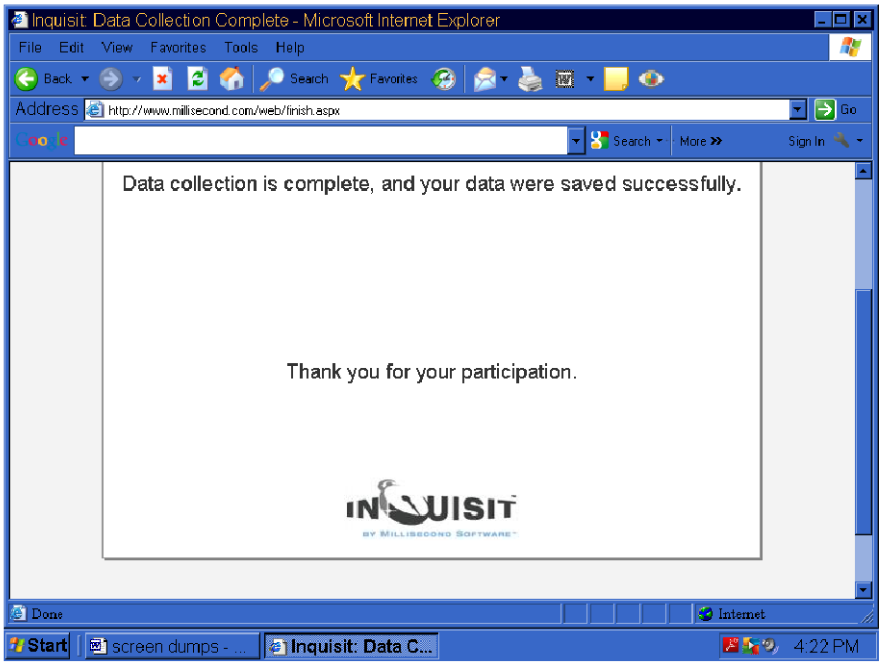
The ***spacebar*** moves you from one instruction screen to the next and starts the first trial.

Number keys to enter your estimation after the presentation of dots. Note you can use keys on a numeric key pad if you have one, or you can use the numbers along the top of the alphabetical keyboard if you prefer.

A combination of the ***Ctrl key*** and the ***Enter key*** is required to record your response. The easiest way to do this is to hold down the Ctrl key then press the Enter key.

The practice session is complete once the Dot Estimation Task is done. Therefore, to exit the session press the ***Ctrl key*** and the ***Q key*** to finish the session. Again, it is easier if you hold down the Ctrl key and just press the Q key.

Once the program has closed you will see the following message:



You can then close the page by clicking on the small square with an X at the top right hand corner of your screen.

agedriving.com Your 4 digit ID number: 2060

Notes and Hints

If you have to leave the computer before all three tasks have been completed:

Sometimes things happen that interrupt your practice session and you may not be able to complete all tasks. If you can, complete the task you are doing but if you can't do this, you can still end the session in the middle of a task.

> To end the session at any time: press the **Ctrl key** and the **Q key** at the same time.

This is the same thing you do once you have completed all tasks and you are ready to end your session. The screen (previous page) noting the collection of data and thanking you for your participation will appear and you can close the web page. It is important you end the session by using the Ctrl Q command otherwise the session remains open and may corrupt any data that you have contributed during this session.

If you have to skip an individual task:

There may be some reason you wish or need to end a particular task but you are able to continue with the remaining task(s). You can jump directly to the next task even if you have already started the task you wish to skip.

> To skip to the next task at any time: press the **Ctrl key** and the **B key** at the same time.

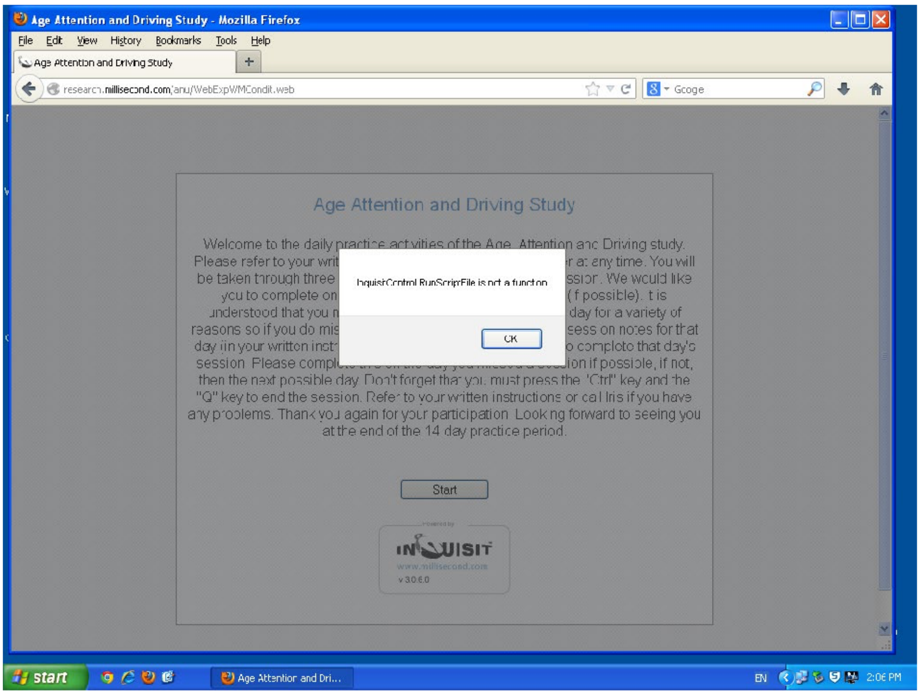
This way you can opt out of a particular task but continue with the other tasks. An example is if the telephone rings and rather than leave the task run without anyone responding you could press the Ctrl and B keys which would move you to the beginning of the next task. You could take your call and return to the remaining tasks when you are ready.

agedriving.com **Your 4 digit ID number: 2060**

Troubleshooting!

The following are computer type things that may happen and prevent you from starting or completing your daily practice tasks. These events have been investigated and some solutions or alternatives provided. You may encounter something not on this list – if so; I would love to hear about it as soon as practical so I can try to address the problem.

1. You may have updated to the latest version of Firefox web browser and you get the following message after you have entered your id number:



The message reads: InquisitControl.RunScriptFile is not a function.

This error occurs with the latest upgrade of Firefox but older versions do not have this problem. If you encounter this problem, switch to using Internet Explorer as your browser.

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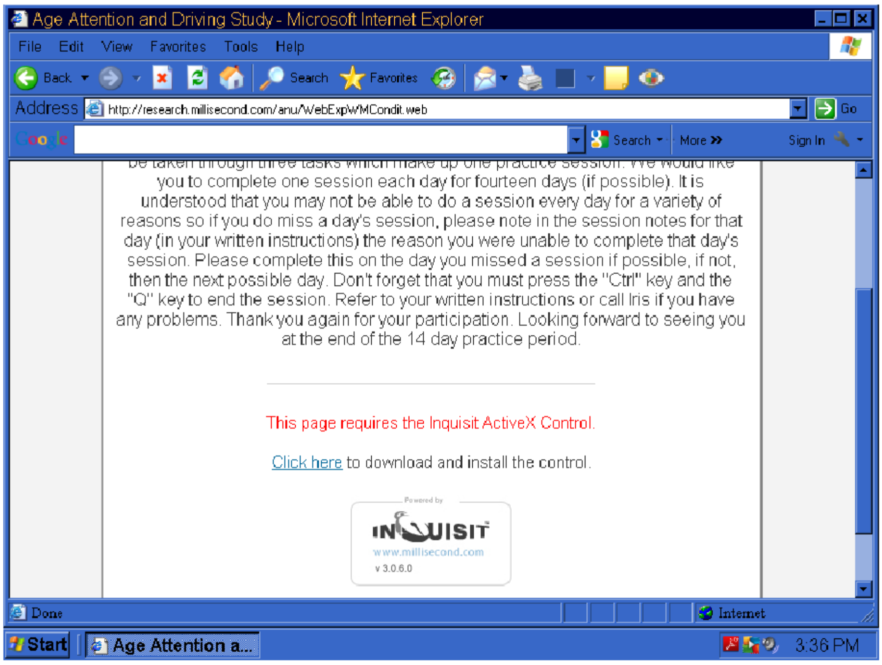
agedriving.com **Your 4 digit ID number: 2060**

This is the Internet Explorer icon. Click on it to open up this browser rather than using Firefox.

2. When you first click on the "Start" button in the "Age and Driving Study" page a message may appear:



The message reads: This page requires the Inquisit ActiveX Control.

This is a similar message to the one that requests you download the Inquisit Web program mentioned earlier in the instructions and is also about loading the program onto your computer. Click on the blue "Click here" and the following message will appear:

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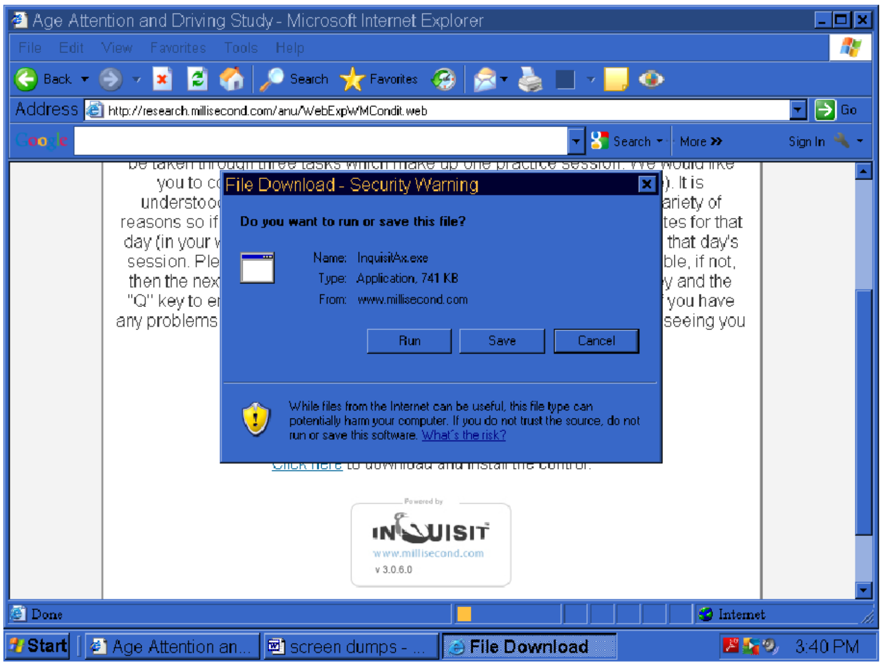

This message reads:

File Download – Security Warning

Do you want to run or save this file?

Name: InquisitAx.exe

Type: Application, 741 KB

From www.millisecond.com

Run Save Cancel

! While files from the Internet can be useful, this file type can potentially harm your computer. If you do not trust the source, do not run or save this software. What's the risk?

In order to run the practice tasks, the computer program needs to load some program files onto your computer. Therefore, if you click on Run, loading the files from the internet will commence. Once all the required files have been downloaded the following message box appears:

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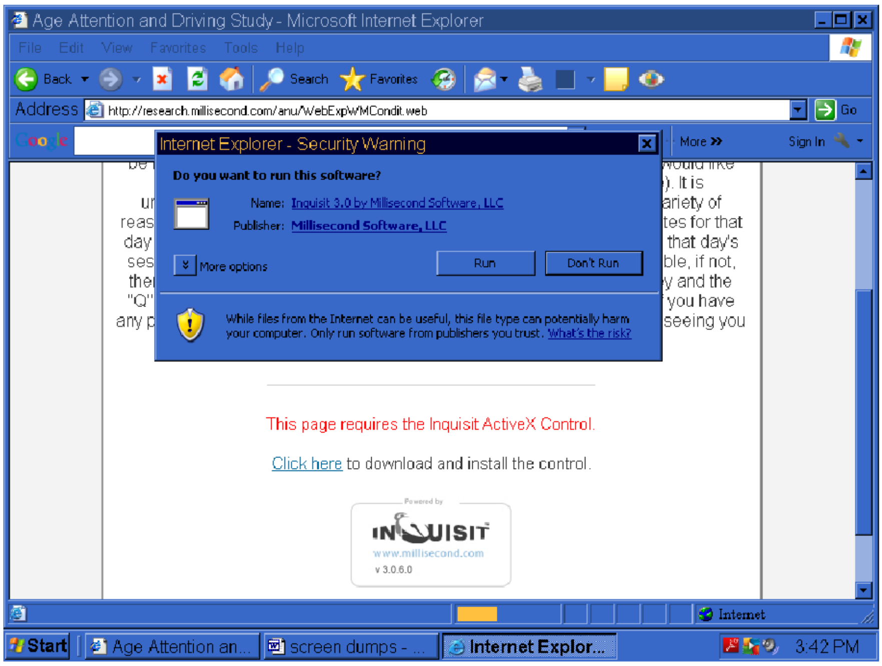

This message reads:

Internet Explorer – Security Warning

Do you want to run this software?

Name: Inquisit 3.0 byMillisecond Software, LLC

Publisher: Millisecond Software, LLC

More options Run Don't Run

! While files from the Internet can be useful, this file type can potentially harm your computer. Only run software from publishers you trust. What's the risk?

Running the program enables the practice tasks to run on your computer, so click on Run. The following message box will appear:

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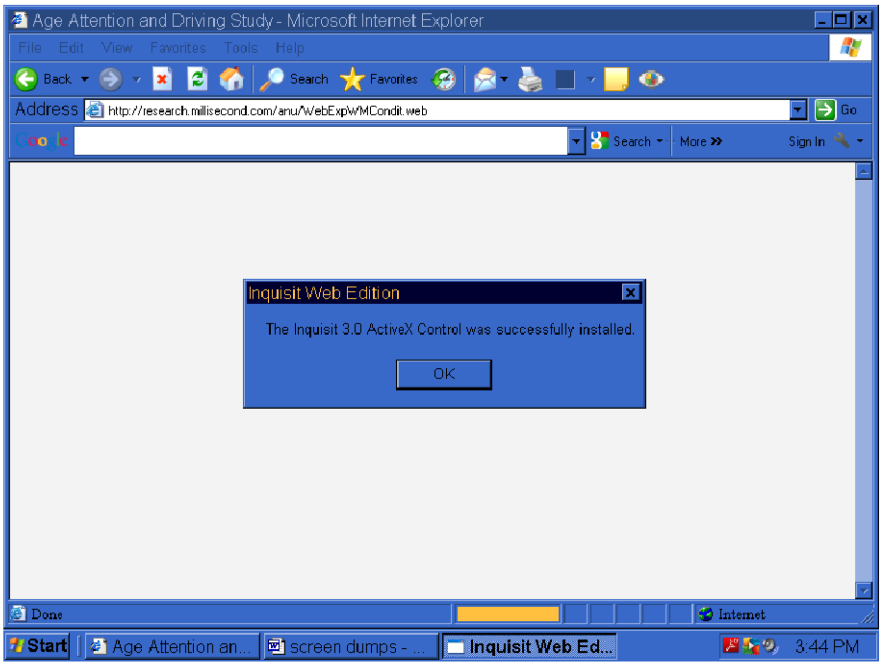
agedriving.com **Your 4 digit ID number: 2060**



This message reads:

Inquisit Web Edition

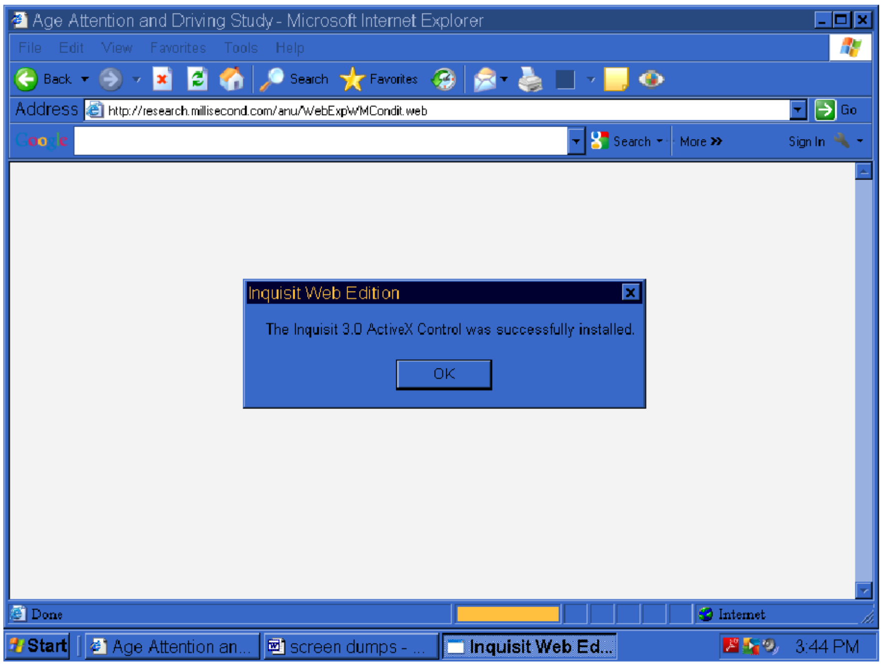
The Inquisit 3.0 ActiveX Control was successfully installed.

OK

This message is to confirm the successful loading of the required program files. The purpose of clicking the OK button is to resume starting the practice tasks.

On some computers the following message will appear:

agedriving.com **Your 4 digit ID number: 2060**



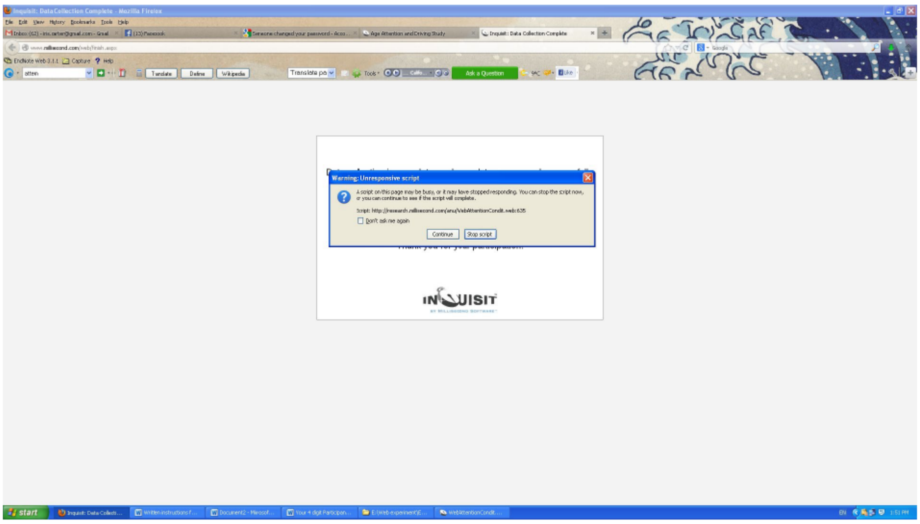
This message reads:

Inquisit Web Edition The Inquisit 3.0 ActiveX Control was successfully installed. OK

This message is to confirm the successful loading of the required program files. The purpose of clicking the OK button is to resume starting the practice tasks.

On some computers the following message will appear:

3. You have entered your 4 digit ID number and the OK key is unresponsive until the following message pops up:



The message reads:

Warning: Unresponsive Script

A script on this page may be busy, or it may have stopped responding. You can stop the script now, or you can continue to see if the script will complete.

Script: http://research.millisecond.com/anu/WebAttentionCondit.web:635

☐ Don't ask me again

Continue Stop script

If you see this screen, click on the *Continue* button and wait a minute or two to see if the program starts. If the program does not start click on the *Stop script* button and go back to the *agedriving.com* web site and start again.

agedriving.com Your 4 digit ID number: 2060

14 Day Session Diary

How to complete your daily diary

The following pages are your 14 day session diary which gives you the opportunity to provide some information about how you are feeling. Your mood at the time of doing the practice tasks may affect how you perform. Also, events that occur during the day may also affect your willingness and ability to do the practice. The diary provides you with an opportunity to share your thoughts and feelings when you first sit down to do the practice as well as when you are done.

The suggested "moods" are not a complete list, nor are they suggestive of any mood we are expecting. They are just some ideas. If one of the suggestions fits how you are feeling, circle it. If none fit, write in a better description on the line below the list of mood words.

Also, if you do not get to the practice on any day, if you are happy to give us some brief information about why you could not do the tasks on a missed day we can add that information to our data collection. It may have been due to a busy day, visitors, or maybe just not in the mood. Whatever the reason, we would really appreciate - if you are happy to share.

The ultimate objective is to develop an on-line practice regime that will transfer to driving skills and confidence and so knowing the nature of things that prevent practice will add to the final design.

So, if you didn't get to the practice, and you are happy to share, jot down a line or two in the "Any other comments" section.

Q

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Your 4 digit ID number: 2060

Day 1

Day of week (eg, Monday): FRIDAY

Date &Time: 7/3/14 8.30pm

How are you feeling at the time you sit down to do today's practice session?
Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad
melancholy impatient annoyed anxious guilty rushed tired

eagerly anticipative

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad
melancholy impatient annoyed anxious guilty rushed tired

alert

Any other comments?

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Your 4 digit ID number: 2060

Day 2

Day of week (eg, Monday): SATURDAY

Date &Time: 8/3/14 6.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

SLIGHTLY ANXIOUS (about wife's health)

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

CALMER

Any other comments?

Wife very ill

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Your 4 digit ID number: 2060

Day 3

Day of week (eg, Monday): SUNDAY 9/3/14

Date &Time: 8.30pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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Your 4 digit ID number: 2060

Day 4

Day of week (eg, Monday): MONDAY 10/3/14

Date &Time: 6.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

CALMER and MORE ALERT

Any other comments?

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Your 4 digit ID number: 2060

Day 5

Day of week (eg, Monday): TUESDAY 11/3/14

Date &Time: 9.00pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Less anxious

Any other comments?

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Day 6

Day of week (eg, Monday): WEDNESDAY

Date &Time: 12/3/14 11.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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Day 7

Day of week (eg, Monday): THURSDAY

Date &Time: 13/3/14

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

TOO BUSY

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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Your 4 digit ID number: 2060

Day 8

Day of week (eg, Monday): FRIDAY

Date &Time: 14/3/14 3.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

____

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

____

Any other comments?

____

____

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Your 4 digit ID number: 2060

Day 9

Day of week (eg, Monday): SATURDAY

Date &Time: 4.00 pm 15/3/14

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

a little more anxious

Any other comments?

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Your 4 digit ID number: 2060

Day 10

Day of week (eg, Monday): SUNDAY

Date &Time: 8.30 16/3/14

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

a little anxious

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

a little anxious

Any other comments?

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agedriving.com Your 4 digit ID number: 2060

Day 11

Day of week (eg, Monday): MONDAY

Date &Time: 17/3/14 9.15.pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

a little less tired

Any other comments?

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agedriving.com Your 4 digit ID number: 2060

Day 12

Day of week (eg, Monday): TUESDAY

Date &Time: 18/3/14 4.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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agedriving.com **Your 4 digit ID number: 2060**

Day 13

Day of week (eg, Monday): WEDNESDAY

Date &Time: 19/3/14 1.00 pm

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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Day 14

Day of week (eg, Monday): THURSDAY FRIDAY

Date &Time: 20/3/14 Midnight 21/3/14 11:30am

How are you feeling at the time you sit down to do today's practice session?

Circle one or write your own description on the line below:

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Anxious

Now you have completed today's practice session:

How are you feeling now you have completed today's session?

happy cheerful calm excited lethargic relaxed angry sad

melancholy impatient annoyed anxious guilty rushed tired

Any other comments?

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Appendix IV. VAS Test Anxiety

Session________________ Participant No:______________

How are you feeling about doing the computer based tests?

In general?

Calm_______________________|_______________________**Anxious**

The visual search task (red square)?

Calm_______________________|_______________________**Anxious**

The Useful Field of View task?

Calm_______________________|_______________________**Anxious**