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The Impact of Alcohol on the Different Components of Working Memory

A thesis submitted to the Faculty of Humanities, in fulfilment of the requirements for the degree of Doctor of Philosophy, University of the Witwatersrand, Johannesburg, 2018

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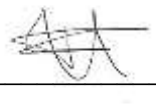
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Declaration

I declare that this dissertation is my own, unaided work. It is being submitted for the degree of Doctor of Philosophy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other university.



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Ingrid Opperman

Abstract

Alcohol consumption related deficits on complex executive functions and short-term memory have been reported in the literature, usually based on group comparisons. A repeated measures design was used, assessing 21 to 35 year old male participants (n = 16) on the Automated Working Memory Assessment's twelve verbal and visuo-spatial short-term and working memory subtests. A low dose of alcohol (13.6 grams) was administered, breath alcohol concentration (BAC) was measured and subjective feelings of stimulation were assessed on the Brief Biphasic Alcohol Effects Scale (B-BAES). Repeated measures analysis of (co)variance models indicated that performance improved on the working memory processing tasks, particularly in the verbal domain. This may have been related to changes in attention functions, stimulus evaluation task demands and tacit recall. However, several of the short-term memory tasks deteriorated under the experimental condition, where Word Recall was significant when age was controlled for. This may have been due to alcohol-related changes in stimulus representations. Partial correlation coefficients suggested that higher BACs were related to deficits in performance if participant age was controlled for. The structure of the B-BAES was consistent with the literature, but subjective feelings of stimulation were not associated with performance changes. Shorter test-retest delays were slightly associated with improved performance, but the research data did not fully support practice effects or a mitigating influence of alcohol consumption. Based on the findings, the specific influence of alcohol consumption on working memory could depend on methodological design, task types, memory domain and other sources of variance.

Keywords: Acute alcohol consumption, alcohol dosage, breath alcohol concentration, Working memory, Short-term memory, Automated Working Memory Assessment, Brief Biphasic Alcohol Effects Scale

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Chapter 1

Introduction

The ingestion of alcohol (ethyl alcohol) in various forms is endemic to most societies. Conservative estimates of prevalence of use in South Africa are estimated at around 50% for men and 20% for women (M. Schneider, Norman, Parry, Bradshaw, & Plüddemann, 2007). Today, alcohol is freely available subject to legal restrictions related to the age of the consumer. However, age restrictions surrounding consumption (18 years old in South Africa) are not always enforced and binge drinking levels (>5 drinks in one day over one or more frequent occasions) in South Africa are among the highest globally (Setlalentoa, Pisa, Thekisho, Ryke, & du Loots, 2010). Negative alcohol-related consequences, such as violence, transport-related deaths, obesity, gastro-intestinal disturbance and familial troubles, appear to outweigh the potential benefits of moderate alcohol consumption (Ramsoomar & Morojele, 2012; Setlalentoa et al., 2010). Ingestion of alcohol, physiologically, results in a cascade of effects on both bodily functions and global functions such as cognition.

Many bodily systems are impacted by the ingestion of alcohol, but the central nervous system is the most strongly influenced (Victor, 1992). Following ingestion, bacterial fermentation in the gut results in absorption of ethanol as an exogenous compound through the lining of the gastrointestinal tract, thereby allowing distribution via the bloodstream and resulting in physiological/behavioural alterations (intoxication) (Lieber, 1992). Although variations in signs of intoxication can be observed and reported at different blood/breath alcohol concentration (BAC) levels, a clear one-to-one relationship does not appear to exist and alterations in behaviour are subject to individual variations (Begleiter & Platz, 1972). Even at low levels, ingestion of beverages containing ethyl alcohol results in neurobiological reactions impacting motor coordination, movement, attention, rehearsal, memory storage, executive ability, reasoning and other processes (Pihl, Paylan, Gentes-Hawn, & Hoaken, 2003; Saults, Cowan, Sher, & Moreno, 2007; Steele & Josephs, 1990; Weissenborn & Duka, 2003). A thorough understanding of the impact of alcohol on working memory (a key component of executive functioning) can assist in better understanding and preventing some of these negative cognitive and behavioural consequences.

Cognitive functions impacted by alcohol, such as working memory, have been implicated in social phenomena such as stereotype threat, emotion regulation and intrusive thought suppression (Redick et al., 2012). However, disagreement exists regarding the precise effects of alcohol on specific cognitive functions, such as working memory, particularly regarding the timing and dosage of consumption (Montgomery, Ashmore, & Jansari, 2011; Saults et al., 2007; Weissenborn & Duka, 2003). Inconsistencies in published research also exist due to the use of laboratory tasks versus real-word tasks of cognitive processing,

differential timing and dosage of alcohol consumption (Montgomery et al., 2011; Weissenborn & Duka, 2003). Inconsistencies in research findings are primarily due to methodological variability in studies of the impact of alcohol on short-term, and working, memory. Task choice for the measurement of working memory is one of the most common sources of this inconsistency. Tasks examining working memory are complex and rooted in a variety of theories. Therefore, difficulties in the interpretation and comparison of findings are frequently the result of a lack of consideration of the theoretical underpinnings of the definition(s) of working memory on which tasks are based.

The research reviewed has demonstrated that studies of the effects of alcohol on working memory have focused on working memory as a single domain able to be assessed by a specific task. However, working memory is a complex constellation of theoretical and measurable components. The multi-faceted nature of working memory has led to numerous theories being put forward regarding its nature, dynamics and measurement. Theories also debate the differences between working memory and short-term memory as to whether these facets operate in tandem or in isolation. Research focusing on the effect of alcohol on working memory has viewed it as a global construct rather than as an assemblage of interactive components. As a result, working memory has not always been clearly defined in literature surrounding the potential impact of alcohol on the tasks selected for its measurement. The absence of clear theoretical underpinnings for task choice results in challenges in comparing the literature. Findings are also difficult to replicate due to the mentioned methodological variability related to tasks types, methods, timing and dosage.

Some studies have utilised multiple task types assessing working memory alongside other constructs such as inhibitory control (e.g. Field, Wiers, Christiansen, Fillmore, & Verster, 2010; Finn, Justus, Mazas, & Steinmetz, 1999), attention to stimuli (e.g. Duka & Townshend, 2004) and decision making (e.g. George, Rogers & Duka, 2005; Montgomery et al., 2011). In these cases, researchers have attempted to operationalise working memory in terms of understanding the impact of alcohol on "real-world" type tasks. Others focused on a psychometric understanding of working memory (cf. Lyvers, & Maltzman, 1991; Murata, Kawashima, & Inaba, 2001; Saults et al., 2007). However, these studies have provided a single, clear, theoretical orientation for their selection of task choice or methodological framework. As a result, it is difficult to replicate results if the impact of alcohol on working memory is framed as a global construct rather than a situation-specific cognitive activity. Therefore, a consideration of the impact of alcohol on theoretically framed working memory functions and

components, as well carefully motivated task choice is necessary. These challenges are discussed further in upcoming chapters.

Theoretical factors to consider in prior investigations of the effects of alcohol on working memory include the nature of working memory and whether it can be fractionated into separate visual and auditory skills and processes, whether working memory is separable into short-term and executive components as hypothesised by Baddeley and Hitch (1974) or whether it represents an embedded, global construct as hypothesised by Cowan (1997). Researchers have not effectively addressed these theoretical considerations prior to investigating the effect of alcohol on working memory. The wide variety of working memory models and conceptualisations of working memory within research on the influence of alcohol consumption has resulted in the use of both construct specific tests, focusing on tests separating components such as auditory and visual short-term and working memory (e.g. Alloway, 2007), as well as more global tests of executive function (e.g. Shallice, 1982). Examples of global executive function assessments include those involving planning, such as the Tower of London Test (Shallice, 1982), assessments incorporating task switching, attention, planning and other components such as the Trail Making Test (Gaudino & Squires, 1995; Reitan, 1955) or tasks such as the Go/No-Go paradigm which require impulse control, memory and decision making (Donders, 1969; Gomez, Ratcliff, & Perea, 2007). This wide variety of tasks can be broadly linked to components and theories of working memory, resulting in an enormous set of options for researchers (Conway et al., 2005). As a result, the idea of working memory as a distinct ability is theoretically useful but not always practically possible during investigative and experimental studies. Additionally, many existing studies are limited due to extraneous variables linked to sampling and methodology.

The current research intends to address some of the inconsistencies between studies through a focused methodology, as well as clear grounding of the assessments utilised within a theoretical framework. This focused approach intends to clarify the specific impacts of alcohol on working memory rather than considering working memory as a single global function. To achieve this, this study was grounded in the Baddeley and Hitch (1974) model of working memory inclusive of subsequent revisions. This model provides a clear basis for the separation of short-term and working memory, as well as the visuo-spatial and verbal/auditory components. As a result, a more comprehensive, structured picture of working memory is produced. Although the model is based on similar empirical evidence to others (e.g. Cowan, 1997; Ericsson, & Kintsch, 1995), it provides clearer opportunities to assess underpinning processes in short-term and working memory, as well as sample-related covariates.

Additionally, the model of working memory used has garnered considerable empirical support (Baddeley, 2012; Shah & Miyake, 1999). This grounding provides a basis for the task choices to assess each of the underlying components of the model, including the distinction between short-term (simple) and working (complex) memory. A secondary focus of this study is to address the methodological factors likely to impact the comparability and comprehensiveness of findings regarding the impact of alcohol on working memory. Specifically, methodological issues were addressed by including the use of multiple task types, a matched pairs repeated measures method, multiple breath alcohol concentration measurements, accounting for subjective feelings of stimulation and consideration of participant physical and lifestyle characteristics. By using a more comprehensive design, inconsistencies present in prior research may be clarified or addressed thereby allowing a meaningful contribution to theory surrounding the impact of alcohol on working memory.

Chapter 2

Theoretical Conceptualisation of Working Memory

A Brief History of Working Memory

Working memory has been conceptualised as a combination of short-term storage and manipulation of information potentially interfacing with long-term memory systems (Baddeley, 2012). A more general definition of working memory has subsequently emerged as a set of cognitive processes within a limited capacity system for temporary maintenance and storage of information (Shah & Miyake, 1999). This system interfaces with peripheral systems, primarily visual and auditory, as well as long-term memory to enable dynamic processing of information (Baddeley, 2003; Logie, 2011). Following the initial development of the modal models of memory, theories have since been dominated by the concept of stores and/or processes as well as the transfer of information (Craik & Lockhart, 1972). Modern models of working memory have generally been conceptualised as containing multiple components which interact in some way, be it multiple specialised 'pockets' of cognition (Baddeley & Logie, 1999), interactions between attention and memory as embedded processes (Cowan, 1999) or the interface of different systems of memory (Ericsson & Kintsch, 1995). The origins of modern definitions relate to early attempts to develop models (rather than theories) of memory and attention. Although definitions and conceptualisations of working memory came to encompass a variety of theoretical assumptions, the primary focus has been founded in the functional cognition underlying processing and temporary storage, attempting to account for a range of observed empirical data (Logie, 2012).

Very early references to working memory and retention referred to contemplation and the power to revive ideas in the mind. This view separated a temporary workspace from a permanent storage space (short-term versus long-term memory). In keeping with this concept, theorists later developed the idea further, distinguishing between a primary and secondary memory system where information in primary memory could be displaced, or replaced, by new information unless it was maintained by some sort of rehearsal or 'copying' of information into secondary memory as a long-term store (Logie, 2012). Some foundation work in this area included Miller's (1956) concepts of variance (amount of information) and covariance (amount of transmitted information), along with his discussions on the ability of the mind to hold seven (plus or minus two) pieces of information at a time in a limited capacity system. Furthermore, Broadbent's (1957) limited capacity systems and channels and Atkinson and Shiffrin's (1971) expansions to include findings of U-shaped recall functions and, importantly, control processes expanded the body of empirical data available. Following these early theories, researchers such as Baddeley and Hitch (1974), Craik and Lockhart (1972), Cowan (1997) and Ericsson and

Kintsch (1995) expanded theories to include more specific modular organisations, levels of processing, the concept of embedded processes and interactions with long-term memory. These theories were built on empirical evidence first observed in the 1950's and expanded to incorporate the latest information as a wider variety of empirical findings surfaced.

Building on initial findings regarding the limited capacity of memory (Miller, 1956), Broadbent (1957) discussed model building with specific reference to working memory, agreeing that perceptual systems were indeed of limited capacity and dependent upon selective inputs into the system. These channels were described as dependent upon the intensity, recency, hierarchy of channels and information in a long-term, permanent, memory store. According to this early model, prior to the selective operation, incoming information is held in a temporary store prior to passing to the more permanent store through the selective perceptual input channel also permitting return to the temporary store. Broadbent's (1957) model was mechanical in nature, linked memory and attention and furthered understandings of experimental tasks of free recall. This U-shaped model was used as a basis for many future working memory understandings, despite being somewhat abstract.

Broadbent's (1957) early model development was based on findings of a U-shaped curve of memory recall for serially presented items. As a result, working memory was originally espoused as a unitary function, only later being reformed to encompass dual-storage mechanisms for separate short-term memory which is subject to decay and long-term memory which is subject to retrieval errors due to change in context or forgetting (Cowan, 1997; Shah & Miyake, 1999). In early theories of working memory, the concepts of a short-term store (STS), rehearsal, attention and long-term memory were pivotal, particularly for Atkinson and Shiffrin's (1971) influential dual-storage model. Atkinson and Shiffrin's (1971) model expanded upon Broadbent's efforts at building models of theories. The model retained some of Broadbent's (1957) aspects such as environmental inputs and channel selection. However, the model moves further than this simplistic explanation, including aspects such as sensory registers and control processes.

The Atkinson and Shiffrin (1971) dual-storage model, originally based both on behavioural observations and computer models of behaviour, postulates that environmental information is processed by sensory registers in various physical modalities and then enters a short-term store (STS) where it temporarily remains. The STS was of importance to this model since its processes are under the immediate control of the individual. Control processes govern the way information flows within the memory system and, therefore, have consequences for performance. Furthermore, control processes permit interaction between the STS and the long-

term store (LTS). The length of time information remains in the STS is dependent upon control processes, but it may be copied to the long-term store. It is possible that information from the LTS, which is associated with the content of the STS, may be activated whilst being retained temporarily. For example, the verbal label "triangle" would be activated and transferred into the STS from the LTS when the visual environmental stimulus of a picture of a triangle is represented in the STS via the sensory register. Once it is understood that some form of interaction occurs between the STS and LTS, specific control processes become important in Atkinson and Shiffrin's (1971) explanation of the dual-storage processes of memory.

The Atkinson and Shiffrin (1971) model proposes that control processes active in the STS impact the output produced after information enters the store. A variety of processes were postulated, namely, rehearsal (voluntary repeating of information), coding (enhancement of long-term retrieval by connecting information to different, easily retrieved information), imaging (remembering verbal information through visual images), decision making and general retrieval strategies. These processes allow the information to either remain in the STS for a longer period or more effective interfacing with the LTS to ensure transfer to that store. Alternatively, it is possible for information to be transferred to the STS via other control processes such as retrieval strategies or deliberate decision making. This information must still either produce an output, or be rehearsed, otherwise it will be lost from the STS. Therefore, each of the control processes was postulated to interact with the STS and LTS in a different manner to produce an output. Experimental evidence is available for the existence of these control processes and some components of the model still provide a partial basis for more complex working memory models.

Optional control processes such as rehearsal, decision rules, organisation schemata, retrieval strategies and problem-solving techniques have also been investigated in relation to the dual-storage model. Task choices in the investigation of the dual storage model were based on the fact that the model supposes that the choice of strategy leads to the selection of relevant information, an activation of the long-term store and transfer of relevant information to the short-term store followed by a decision to terminate or continue the search and, if continued, some sort of output (Atkinson & Shiffrin, 1971). Investigations at this point related primarily to the rehearsal component of the model and, therefore, the movement of information between the STS and LTS (Atkinson & Shiffrin, 1971).

Free recall, digit span and serial presentation tasks were commonly utilised in early investigations of working memory. Such tasks, utilised by early researchers, produced U-shaped recall functions and sparked discussions of primacy effects, recency effects and

interference (Baddeley, 2003). These findings were influential in forming the basis of later theories. The primacy effect refers to the increased probability of recall for words presented at the beginning of a list while the recency effect refers to increased probability for words presented at the end of a list. These probabilities, coupled with decreased likelihood of recall of the central words in the list, are utilised to explain the apparent U-shaped recall function described by Atkinson and Shiffrin (1971). Atkinson and Shiffrin (1971) investigated the effects of interference in list recall tasks, finding that interference appeared to cause a loss of information in the STS, allowing retrieval only from the LTS. In addition, Atkinson and Shiffrin (1971) found that delaying recall caused an elimination of the recency effect as only the LTS was accessed. On the other hand, extended list lengths caused an elimination of the primacy effect as there was no opportunity for transfer to the LTS. Such findings related to Broadbent's (1957) tasks and modelling have formed the foundation for more sophisticated theories and modern models (Baddeley, 2003). Craik and Lockhart's (1972) research emphasised the importance of elaborate processing, thus incorporating more levels of working memory and focusing on the framework for transfer of information rather than simple storage models.

Multi-store and dual-store models are appealing as they present well-regulated paths and control features along with designated stores with specific characteristics. However, such models may be missing important aspects in their formulation relating to capacity, coding and retention functions (Craik & Lockhart, 1972). Craik and Lockhart (1972) discuss short-comings in the experimental findings based on Atkinson and Shiffrin's (1971) dual-storage model. The limitations in capacity of the STS are unclear in relation to processing capacity, storage capacity or the interaction between the two. Craik and Lockhart (1972) emphasised that measurement of capacity leads to a storage only interpretation of the STS (i.e. capacity is measured by the number of items stored on the appropriate scale of measurement). Craik and Lockhart (1972), therefore, postulated that a more flexible system limited by short-term storage capacity is more appropriate and permits the holding of both sensory coded information and semantic information.

Despite agreement with Atkinson and Shiffrin's (1971) basic tenets, Craik and Lockhart (1972) argued that it may be that retention depends on aspects of the experimental paradigm such as study time, amount of material and mode of testing. These factors could affect the outcome of working memory studies due to their effect on different tasks. Overall, their focus turned to more complex tasks emphasising the study of elaborative processing, coding and retrieval, semantic associations linked to sensory inputs, meaningful links with long-term

stores and instructions to learn information impacting processing and task performance (i.e. the use of strategies in remembering). These complex phenomena highlight the weaknesses of early modal models which could not account for considerable amounts of the available experimental data (Schacter & Tulving, 1994).

A variety of models of working memory have since been put forward but, for the purposes of this research, an overview of the elaborate embedded processes model developed by Cowan (1999) and the long-term working memory model developed by Ericsson and Kintsch (1995) will be given. This discussion highlights differences explaining the importance of the extensively researched Baddeley and Hitch (1974) modal model (and later additions and elaborations) which will be utilised as the foundation model for the working memory tasks used in the present study. The Baddeley and Hitch (1974) model best lends itself to experimental assessment and, unlike many other models, postulates a workable theory of working memory functions, despite being subject to many of the same limitations as other modal models.

Models of Working Memory

Three notable theories of working memory have been developed, namely, that of Baddeley and Hitch (1974), further discussed by Baddeley (1983, 1996, 2010), Cowan (1999) and Ericsson and Kintsch (1995). These theories utilise a more comprehensive definition of working memory, incorporating several aspects. Although working memory is broadly considered a limited capacity system for maintenance and storage of information (Shah & Miyake, 1999), the working memory system also makes use of temporary memory interfacing with long-term memory, as well as peripheral systems. In doing so, this system interfaces with long term memory and peripheral systems, including sensory systems and meta-cognitive processes, for the tracking of ongoing mental processes and changes in information (Baddeley, 2003; Logie, 2011). Therefore, this system permits the individual to utilise a variety of pieces of information instantly whilst learning, reasoning or performing other tasks (Baddeley, 2010). Ericsson and Kintsch (1995) proposed that accounts of working memory should include both temporary storage of information (short-term working memory) and a schemata mechanism based on skilled use of long term memory (long-term working memory). Cowan (1999), however, contended that the links between memory functions and attention in an embedded model were of importance. On the other hand, the Baddeley and Hitch (1974) model of working memory comprises three primary functions, namely, the phonological loop, the visuo-spatial sketchpad and the central executive. While Baddeley and Hitch (1974, 1983) hypothesised that

the phonological loop and visuo-spatial sketchpad were responsible for short-term (immediate) memory in the auditory and visuo-spatial domains respectively, the central executive functions are more complex. The central executive component acts as a supervisory control system, creating an interface for the flow of information from the short-term systems. In this way, information from the two short-term memory slave systems can be integrated, controlled and modified to perform specific tasks. Since the Baddeley and Hitch (1974) model of working memory (and later revisions) forms the foundation of this study, this section discusses the other two primary models of working memory whilst the influential Baddeley and Hitch model is discussed in more detail later.

Ericsson and Kintsch's (1995) Model of Long-Term Working Memory

The potential uses of long-term memory schemata was originally debated following findings of superior performance in spatial perception and short-term memory of piece position in expert chess players (Chase & Simon, 1973). This idea was expanded upon by Ericsson and Kintsch (1995) to incorporate the concept of schemata being utilised in what they described as long-term working memory. Following discussions of semantic 'chunking' of information (Craik & Lockhart, 1972), Ericsson and Kintsch's (1995) theoretical framework incorporated a long-term working memory component introducing some more flexible characteristics in memory. This framework allowed for long-term memory to be involved in both storage and retrieval. Long-term memory may also be incidental as seen in skilled or expert performance using selective storage, retrieval and processing.

Ericsson and Kintsch (1995) argue that accessible storage is only possible for short periods of time unless rehearsal or re-activation is utilised. These two processes are required to relocate information into long-term memory. Such models of long-term working memory may account for the superior performance in experts performing domain specific (but not novel) tasks, as found by Chase and Simon (1973), whereas the dual-process modal model purported by Atkinson and Shiffrin (1971) could not (Ericsson & Kintsch, 1995). Chase and Simon (1973), as well as Ericsson and Kintsch (1995), explain the phenomenon of expert performance leading to superior memory functions as being due to acquired, specific, knowledge and skills permitting complex associations and representations. The complexity of these associations reduces the number of 'chunks' of information to be stored as schemata in long-term memory, allowing for superior performance. The researchers also postulated the existence of latent long-term memory functions resulting in the absence of effortful activity in this type of expert performance, thus allowing anticipation of future retrieval demands and better accessibility of

information within the system. However, this theory is limited in terms of application as it may only include tasks applicable to expert performance and is not extendable to the original findings on word/digit span or free recall such as those discussed by Atkinson and Shiffrin (1971), nor to tasks developed based primarily on models such as that of Baddeley and Hitch (1974) including operations span, reading span, spatial span and dual-task interference paradigms (Shah & Miyake, 1999). Therefore, the theory cannot be applied to latent working memory processes, nor any specific components within the process of working memory aside from the specifically hypothesised chunking and expert performance facets.

Ericsson and Kintsch's (1995) most important assertion in the development of working memory theory is the conceptualisation of an interface between short-term and long-term memory expressed as a function of working memory. However, Vincente and Wang (1998) have cautioned that Ericsson and Kintsch's (1995) theory of long-term working memory cannot account for non-natural phenomena, for example, chess players attempting to recall contrived, or non-natural, positions of pieces on the board (Ericsson, Patel, & Kintsch, 2000). The concept of long-term working memory may be inadequate since the superior facets are representative of, and intrinsic to, the domain of expertise in question as experts are attuned to the constraints of "natural" stimuli and rely on these constraints during presentation and recall (Vincente & Wang, 1998). The argument put forward by Vincente and Wang (1998) relates to a limiting conception of long-term working memory where the construct is defined as deliberate acquisition of mnemonic encoding methods and retrieval structures. These methods and structures are acquired as an extension of the expert skill. In response, Ericsson et al. (2000) argue that maintenance of access to information in long-term working memory and accessibility of encoded information extends beyond the constraints of skilled, expert working memory into the general working memory domain. To better understand these, and similar, working memory findings, researchers such as Cowan (1999) proposed a variation of how working memory operates, integrating concepts which Ericsson and Kintsch's (1995) model did not fully explore.

Cowan's (1997) Embedded Processes Model: The Role of Attention

Cowan (1997, 1999) emphasised the role of attention in working memory processes as an embedded processes model. The role of attention had not been fully considered in modal models of working memory, although it was briefly considered by Atkinson and Shiffrin's (1971) discussions on 'channels' selected for the shifting of information between the short-term and long-term stores. According to the embedded processes model, the link between

working memory and attention is of importance (Cowan, 1997)**.** Cowan (1999) discussed this link through illustration in five principles. Firstly, activated long-term memory, along with a sub-set of active working memory, are hierarchically arranged for focused attention and awareness. Therefore, an activated working memory system is subject to the overarching capacity of a long-term memory system. Secondly, different faculties are subject to processing limitations such as similar features of visuo-spatial stimuli. These types of limitations are important in non-optimal circumstances such as memorisation and recall over extended periods of time. Since the focus of attention is of limited capacity, activation capacity is also limited, particularly by time lapses. Thirdly, control of attentional focus is used in voluntary control via a central executive function whilst involuntary attentional orienting focuses attention. The two attentional components may be incongruent at times during executive memory tasks. Fourthly Cowan (1999) points out that activation of some features of working memory may occur through habituation of orienting due to repeated exposure to familiar features or items which remain relatively stable over time. Habituation of orienting is likely to occur without awareness and is not necessarily directed to features of key importance for the function of working memory. Lastly, awareness of a stimulus influences processing and perception of features. Awareness allows new episodic representations to become available for explicit recall. These principles illustrate a set of embedded systems within an over-arching long-term memory system. Increased awareness increases perception of the number of features encoded, allowing new episodic representations in memory to become available for explicit recall. Therefore, the embedded processes nature of working memory can be visualised as a sub-set of temporarily activated memory within an over-arching long-term memory system.

The embedded processes model describes temporarily activated sub-sets of memory functions within which attention is focused. Therefore, activation is required to attend to information outside the focus of deliberate attention which is jointly controlled by automatic recruitment (responses) and voluntary central executive processes which may be modified by instruction and deliberate effort. It is also possible to deliberately direct attention away from a stimulus to reduce memory load, as evidenced in tasks utilising extraneous stimuli or distractors (Cowan, 1999). The three components of the embedded processes model, namely, activation, focused attention and long-term memory, represent an expansion of Ericsson and Kintsch's (1995) model emphasising the relationships between attention and memory.

Neither Ericsson and Kintsch (1995), nor Cowan (1997), managed to successfully fully integrate Ebbinghaus' (1964) original evidence of short-term memory storage (e.g. digit-span, primacy effects, recency effects and the forgetting curve) with long-term memory, attentional

activation and peripheral systems. Theorists have attempted to develop a more comprehensive model of working memory based on early experiments (Baddeley & Hitch, 1974; Baddeley, 2003), which includes components such as active rehearsal/attention, the role of peripheral systems, short term memory, rehearsal and interfacing/encoding in long-term memory (Cowan, 1999; Baddeley & Logie, 1999; Ericsson & Kintsch, 1995). The influential Baddeley and Hitch (1974) model has become the foundation for many investigations of working memory as it lends itself to specific task types and comparisons of components.

The Baddeley and Hitch (1974, 1983) Modal Model of Working Memory

Baddeley and Hitch (1974) and, later, Baddeley (1983), argued for the separation of short-term and long-term memory systems using three sources of evidence. Firstly, two-component tasks appear to reveal a relatively stable long-term memory component separate and distinct from a more labile short-term component. Secondly, patients with memory disorders, such as Korsakoff's syndrome, appear to have disrupted long-term memory learning capacity but still evidence a normal short-term memory span. For example, H.M. demonstrated severe anterograde amnesia for short-term memory events such as digit recall tasks, but premorbid long-term memory remained intact (Milner, Corkin, & Teuber, 1968). Others have also noted dissociations with disrupted short-term memory span which is not attributable to long-term retrieval failure (Shallice & Warrington, 1970). Therefore, Baddeley (1983) described the phonological loop component of the earlier Baddeley and Hitch (1974) modal model as differential encoding for short-term recall based on phonological characteristics rather than long-term stores. Short-term recall was hypothesised to be impacted by articulation similarities, subject to errors in recall or reproduction, known as the phonological similarity effect. On the other hand, long-term stores relied on semantic encoding and retrieval, separate from processes impacting short-term stores. This type of separation was in opposition to unitary views of working memory and formed the foundation for the modal model similar in structure to that proposed by Atkinson and Shiffrin (1971) (Baddeley, 2003).

The Baddeley and Hitch (1974) modal model is somewhat different to the embedded processes models, attention activation models and constraint attunement hypotheses proposed by researchers such as Ericsson and Kintsch (1995) and Cowan (1999). The Baddeley and Hitch model stresses the multi-component character of working memory as well the functional importance of working memory in facilitating a range of cognitive activities (Baddeley, 2012). The early range of cognitive activities and tasks explained by the Baddeley and Hitch model has been superior to the limited number of tasks or findings (e.g. digit span or expert

performance) explainable by other models. Initially, the three-component model stressed the importance of peripheral and processing systems in complex working memory. These systems are the phonological loop, visuo-spatial sketchpad and central executive (Baddeley, 2003). Later research provided some evidence of the neuroanatomical localisation of these primary components, affirming the potential accuracy of the model description (Chen & Desmond, 2005; Müller & Knight, 2006; Cabeza & Nyberg, 2000).

The phonological loop. The phonological, or articulatory, loop is a sub-system (slave system) of working memory responsible for articulatory rehearsal and maintenance. The concept was originally hypothesised following early work with auditory tasks where differences in encoding were observed dependent upon short-term (phonological) or long-term (semantic) activation in memory (Baddeley, 1983). The phonological loop comprises a phonological store which holds memory traces for a few seconds and an articulatory rehearsal process analogous to sub-vocal speech for maintenance of information (Baddeley, 2010). Simple short-term memory has a limited span since articulatory rehearsal takes place in real time, reaching a point whereby the first item can no longer be held in memory and has faded prior to active rehearsal (Baddeley, 2003). Since vocal or sub-vocal rehearsal is required for maintenance of information in the phonological loop module of the working memory system, information is subject to processes of trace decay and interference which has been demonstrated in a variety of studies including findings supporting the primacy effect (Baddeley, 2012).

Evidence for phonological short-term storage and differential functioning of a long-term system comes from a variety of sources. Baddeley (1983) initially considered the phonological loop as a system able to explain a variety of phenomena, including the phonological similarity effect, the word length effect, the unattended speech effect and the articulatory suppression effect. The word length effect, evidenced by poorer performance when attempting to retain longer words in working memory, is impacted by subvocal or vocal rehearsal. Since rehearsal occurs in real time, longer words take longer periods of time to rehearse resulting in the observed difference in performance. Additionally, open (diverse) sets of words are more likely to reflect item loss, showing evidence that semantic-based and other long-term memory effects are important for more complex remembering (Baddeley, 2012). Suppression of rehearsal through repetition of a single word removes the phonological similarity effect (interference created by two words being phonetically similar) for analogous visual (written or diagrammatic) materials but not stimuli presented in the auditory domain (Baddeley, 2012). Presentation of spoken material results in obligatory and automatic access

to phonological storage systems. On the other hand, memory for written material requires sub-vocalisation. This hypothesis is broadly comparative to attentional allocation theories which propose that a sub-set of information is attended to through temporarily focused and activated attention which may be automatic or deliberately focused. In addition to attentional allocation and findings of phenomena such as the phonological similarity effect, further understanding of the phonological loop has come from evidence provided by imaging and lesion studies such as the case of H.M. (Milner et al., 1968).

The visuo-spatial sketchpad. Baddeley (1983) describes the visuo-spatial sketchpad as a specialist system for maintaining and manipulating visuo-spatial images utilising active storage capabilities. This system binds contextual and constituent features of visual information, such as colour, location and shape, for later retention and/or manipulation. It appears to be limited in capacity (like the phonological loop), focusing on the general binding of constituent and contextual features rather than detail-oriented remembering. This distinction is evidenced in the phenomenon of change blindness, where the removal of insignificant details or objects from visual scenes is often not noticed (Baddeley, 2003).

The visuo-spatial sketchpad was conceptualised following four observations (Baddeley, 1983). Firstly, visual tracking tasks create impairment in performance in spatial memory tasks but not verbal tasks. This dissociation seems to indicate separation of visual and verbal task performance. Secondly, spatial tasks disrupt visual tracking more than verbal tasks, pointing to separation of the spatial and verbal components of working memory. Thirdly, based on experimental observations, the system appears to be primarily spatial rather than visual. Lastly, spatial imagery mnemonics appear to rely on the visuo-spatial sketchpad as they are disrupted by concurrent visual tracking whilst words with high imageability are better remembered than abstract words, regardless of whether concurrent tracking occurs. This finding suggests the use of semantic/imagery associations, rather than purely visual memory devices, during retention of some spatial information. These four observations were utilised by Baddeley (1983) in his further conceptualisation of the visuo-spatial sketchpad or scratch-pad as a specialist subsystem of working memory.

Observations three and four led Baddeley (1983) to suggest that the visuo-spatial sketchpad was a purely spatial system, free of imagery components associated with long-term semantic memory, as is the case for the phonological loop. These findings concur with those suggested by hypotheses of long-term working memory implying that working memory utilises temporary storage as well as drawing on long-term stores and schemata (Ericsson & Kintsch, 1995). It appears that the visuo-spatial sketchpad may be separable into imagery and spatial

components, as postulated by Logie (1986). This notion has been supported by neuroanatomical (Klauer & Zhao, 2004) and working memory (Baddeley, 2012) literature. The proposed "what" (imagery) versus "where" (spatial) distinction is further supported by findings of double dissociations in lesion studies, as well as other from other neuroanatomical sources of evidence (Della Salla, Gray, Baddeley, Allamano, & Wilson, 1999). The spatial component of the visuo-spatial sketchpad is limited by the visual complexity of the representation, storing information for brief periods and holding a recent auditory-verbal description of an array or stimulus (Logie, 2011).

The 'inner scribe' is a component of the visuo-spatial sketchpad responsible for incorporation of long-term memory with perceptual information in a dynamic visual retrieval/rehearsal process which retains short sequences of spatial movements whilst interfacing with stored semantic schemata (Baddeley, 2012; Logie, 2011). This process is separable from a visual cache system utilised as a temporary visual store separate from any rehearsal or manipulation systems (Baddeley, 2012). Visual mental imagery and memory appear to be separately associated with executive functions, stored experience, episodic knowledge and semantic long-term memory (Logie, 2011), providing the 'what' component of the "what" versus "where" dissociation noted by Della Salla et al. (1999). In addition to the "what" versus "where" distinction, a third system of visual processing reliant on kinaesthetic or movement-based components, such as dance or hand gestures, has also been proposed as an adjunct to the visuo-spatial sketchpad (Smyth & Pendleton, 1990). Some believe that the working memory model should include the kinaesthetic system as a third slave- or sub-system (Wu & Coulson, 2014).

Research into the functioning and uses of the visuo-spatial sketchpad component of working memory has been somewhat fragmented and has yet to be fully integrated, particularly regarding the separation of the "what" and "where" components and the separation of short-term (simple) memory from complex (working) memory within each component (Baddeley, 2012). Lesion and imaging studies have further identified potential components of the visuo-spatial sketchpad, lending some support to the concept of the visuospatial sketchpad as a component of working memory with a "what" (object) and "where" (spatial) separation (Baddeley, 2012; Cabeza & Nyberg, 2000; Della Salla et al., 1999; Müller & Knight, 2006).

The central executive. Baddeley (1983) describes the central executive as the core of the working memory system, responsible for coordination of information from subsidiary slave systems in a limited-capacity attentional process capable of selecting and operating control processes and strategies. Therefore, the central executive makes use of habit patterns, schemata

and attentional control whilst integrating information from the phonological loop and visuo-spatial sketchpad peripheral systems (Baddeley, 2003). The central executive is not a well understood component of working memory, having been related to models of attentional control (cf. Cowan, 1999) as well as environmental cues and a supervisory activating system (SAS) which intervenes when routine control is insufficient and non-routine selection is required (Shallice, 1982).

Baddeley (2012) describes a fractionation of the central executive functions through listing of four primary functions or requirements, namely, focused attention, divided attention, specific control and interfacing with long-term memory. The central executive would need to be able to focus attention as well as being able to divide attention between two or more important targets or stimulus streams. Evidence for these fractionations has been found in studies of attention in relation to complex tasks, as well studies utilising Alzheimer's patients' ability to perform single, and dual, tasks such as tracking and recall of series of digits free of long-term memory functions (Baddeley, 1996). A third hypothesised function of the central executive is as a specific control system allowing for alternating attentional focus, suppression of responses (for example, articulatory responses) and task switching. Lastly, Baddeley (2012) discusses the role of the central executive as an interface with long-term memory. This suggestion, like that of Ericsson and Kintsch (1995), implies that the central executive is not a pure attentional control system (cf. Cowan, 1997) and does have some storage capacity.

Baddeley (2012) discusses the role of semantic long-term memory schemata in increased memory span when words made up a sentence rather than being random, as well as research on comprehension, reasoning, learning and response inhibition. Smith and Jonides (1998) offered a similar view of the functions of the central executive, hypothesising that these involved inhibiting response tendencies or automatic responses, selecting mental processes, switching or diverting attention and deliberate coding of information. The functions of inhibition, attention switching and contextual coding or checking have been consistently referred to in studies of the central executive and linked to lesion and imaging research, primarily indicating that executive function is seated in the frontal lobe (Smith & Jonides, 1998). Such neuroanatomical studies provide better understanding of the hypothesised components of the modal models.

The episodic buffer. Baddeley (2012) emphasises the importance of the central executive in attentional control, manipulation of information and interfacing with long-term memory. However, this model, alone, cannot account for more than limited capacity storage of the visuo-spatial sketchpad and phonological subsystems, utilising the central executive during

attentional control, interfacing and manipulation. As a result, the episodic buffer was introduced as a fourth component of the working memory model. The episodic buffer was conceptualised to account for working memory's ability to conduct multidimensional processing, utilise links between the central executive and long-term memory and hold complex representations in memory whilst interfacing with peripheral systems (Baddeley, 2012; Logie, 2011).

The episodic buffer is assumed to be a limited capacity store binding information to form integrated episodes in a manner which is accessible to conscious awareness through attentional control by the central executive (Baddeley, 2003). The buffer permits multi-dimensional coding and integration of peripheral systems in a binding and retrieval process utilising information from sensory information, long-term memory schemata and modality-specific temporary stores (Baddeley, 2003; Logie, 2011). Based on research in Alzheimer's patients' temporary feature binding abilities and concurrent performance in dual task conditions, Logie (2011) considered the possibility of a capacity limited interface between the episodic buffer and long-term memory, combined with interactions with peripheral systems such as the visual cache. This hypothesis differs somewhat from Baddeley's (2003) construction of the episodic buffer since attention is not capacity-limited, as suggested by Ericsson and Kintsch (1995), but rather subject to the combined limited capacities of a range of specialist systems acting together to meet task demands (Logie, 2011).

On closer inspection, Logie's (2011) conceptualisation of the episodic buffer does not actually differ considerably from that discussed by Baddeley (2012). Baddeley (2012) describes the episodic buffer as a medium which permits features from several sources (peripheral systems) to be bound into chunks or episodes perceptually, allowing for new images and items to be held in memory. Baddeley (2012) elaborates that this conceptualisation relies on attentional control of the central executive to access verbal, and visual, constructs which have been bound and coded in separate modalities. Such bindings may be maintained whilst still permitting executive processes to carry out manipulations. Due to the hypothetical nature of the buffer and difficulties in assessment of this component of working memory, particularly in terms of separation from the central executive, researchers have relied on neuroimaging evidence and lesion studies, as well as a consideration of deficits in Alzheimer's patients to better understand the binding function of this component of working memory. Therefore, the episodic buffer is a highly theoretical component and not subject to active task assessments.

Evidence for each of the components of working memory has relied on some form of measurement of the hypothesised process. For example, the visuospatial sketchpad has been

linked to tracking tasks measuring the 'where' component whilst the episodic buffer appears to be neuroanatomically activated in tasks requiring the switching of spatial attention. Task choice has important implications for findings surrounding the model components. Since the Baddeley and Hitch (1974, 1983) model formed the foundation for this study, a brief critique of the described components is appropriate to provide context for the findings.

A Brief Critique of the Baddeley and Hitch (1974, 1983) Modal Model

Cowan's (1997) and Ericsson and Kintsch's (1995) models of working memory focused on attention, embedded processes and the role of long-term memory. Some constructs considered in these models are complementary to the Baddeley and Hitch (1974) modal model. For example, both Cowan's (1997) and Baddeley and Hitch's (1974) models encompass the role of attention. Baddeley (2012) considers the role of long-term memory in a discussion of rehearsal structures in working memory such as the use of linking strategies in rehearsal and reproduction of information. This idea resonates with Ericsson and Kintsch's (1995) conceptualisation of long-term memory schemata as central to working memory. However, the models are largely incongruent despite sharing a few common features. For example, Baddeley and Hitch (1974, 1983) considered working memory and long-term memory as distinct stores rather than as an embedded process, interlinking attention and long-term memory (Cowan, 1999) or long-term memory as integral to retrieval structures during working memory tasks (Ericsson & Kintsch, 1995; Meltzer et al., 2015). As a result, although the Baddeley and Hitch (1974) model provides an intuitively logical understanding of short-term and working memory, some cognitive functions may be more complex than the model describes (Shah & Miyake, 1999).

Models other than the well-known theories put forward by Ericsson and Kintsch (1995) and Cowan (1997) have considered working memory as being less compartmentalised than Baddeley and Hitch (1974) describe, and subject to a variety of other functions. In fact, even at the advent of the compartmental models, an argument was put forward that the concept of the limited short-term memory store was not useful. This argument proposes that since humans can cognitively process and conduct complex tasks, utilising working memory style functions, despite interruptions, that it does not follow that the short-term store is as limited as the modal models describe (W. Schneider & Detweiler, 1987). The general capacity hypothesis suggests that individuals who perform better on working memory tasks have higher attentional capacity in general, as well as greater efficiency of mental operations, including the maintenance of multiple pieces of relevant information (Broadway & Engle, 2011; Conway, Cowan, &

Bunting, 2001; Conway & Engle, 1996; Just & Carpenter, 1992). This concept was presented from a biological/connectionist perspective whereby various structures and regions are connected and responsible for the control of storage and trade-offs for active learning and processing, including those involving long-term memory (W. Schneider, 1993).

The hypothesis that working memory depends partially on global mental operations and attention is expandable to include aspects of long-term memory and learning which may influence the results of tasks such as word recall with a processing component linked to long-term memory (Hulme, Maughan, & Brown, 1991; Unsworth & Engle, 2005). These studies fit in with the idea of semantic coding as well as general chunking, extensively discussed in review by Baddeley (2000) as well as being considered by some other theorists (Belacchi, Benelli, & Dispaldro, 2013; Cowan, Chen, & Rounder, 2004; Daneman & Carpenter, 1980; Gobet, 2000). The argument that both visual and auditory information relates to long-term memory encoding is relatable to the connection between long-term memory and working memory discussed in the Ericsson and Kintsch (1995) model and by other theorists (e.g. Ericsson et al., 2000; Logie, 2011; Shah, & Miyake, 1999). However, the mentioned research examples were seated in linguistic foundations as opposed to short-term and working memory specific tasks, such as word recall and translation, which may involve long-term memory (cf. Baddeley, 2012).

Baddeley (2012) agreed with the contention that long-term memory is somewhat active in learning and/or rehearsal in conjunction with the phonological loop (and potentially the visuo-spatial sketchpad) (cf. Ericsson & Kintsch, 1995; Unsworth & Engle, 2007). Such an idea questions the concept of working memory and short-term memory as an interactive modal system distinct from long-term memory – a point contrary to those raised by both Ericsson and Kintsch (1995) in their discussion of "working long-term memory" and Cowan (1997) in discussion of the role of attention in an embedded processes model. However, Baddeley (2012) contends that the long-term store represents crystallised, rather than fluid, working memory processes. Crystallised knowledge and skills are semi-permanent, learned representations of knowledge. As a unitary model of working memory, the Baddeley and Hitch (1974, 1983) model represents separated, although inter-related constructs capable of fluid activity, which interact when necessary with the crystallised information represented in long-term memory. Unsworth and Engle (2005), on the other hand, provided some evidence that working memory capacity is linked only to deliberately controlled tasks and not to individual differences in fluid, incidental learning and memory tasks. This type of finding is extendable towards further understanding of a potential long-term interface and evidence of automated recall and rehearsal.

A question remains as to whether decay in the phonological loop is due to trace decay, as seen over time, or interference, as evidenced in studies on the suppression of irrelevant information, both visual and auditory (Baddeley, 2002; Chein & Fiez, 2010; Hanley & Bakopoulou, 2003). In answer to this question, working memory has been hypothesised to be divisible into both a primary and secondary system as discussed by Unsworth and Engle (2007) as well as Unsworth and Spillers (2007), the nature of the suppression of irrelevant information may be different than that described by Baddeley and Hitch (1974). In such a case, irrelevant information may corrupt information in primary, conscious, memory depending on how well the available cues match those in secondary, unconscious, memory during automatic retrieval and processing (Neath, 2000; Unsworth, Brewer, & Spillers, 2013; Unsworth & Engle, 2007). This is contrary to Baddeley and Hitch's (1974) contention that irrelevant information inhibits rehearsal leading to the inability to recall information rehearsed in short-term memory.

On the other hand, Cowan's (1997) model hypothesised that the focus of attention or awareness, rather than rehearsal, may be responsible for the impact of "noise" or divided attention evidenced in the articulatory suppression effect and its visual/spatial correlate. Chein and Fiez's (2010) neurologically focused study failed to find evidence for the Baddeley and Hitch (1974, 1983) model explaining the articulatory suppression effect and impact of "noise". However, these authors did find some neurological evidence for the role of attention as per the Cowan (1997) embedded processes model, unless sub-vocal rehearsal becomes an automated function. Similarly, Unsworth and Engle (2005) hypothesised that incidental learning and automated processing do not account for individual differences in working memory capacity during serial recall tasks. Many critiques of the phonological components focus on attention, the impact of divided attention on controlled processing and the suppression of rehearsed information. These components appear interrelated in literature regarding auditory/phonological functioning but may be extendable to issues surrounding the visuo-spatial sketchpad component of the model.

The visuo-spatial sketchpad, like the phonological loop, appears to be subject to interference via noise or divided attention type tasks (Baddeley, 2002). Logie's (1995) discussion of the inner scribe seemed to incorporate ideas from other models. The inner scribe, as a basic mechanism of rehearsal, was hypothesised as connecting both attention and maintenance of activity, similarly to Cowan's (1997) concept. The role of attention has also been discussed in relation to the structure of working memory in attempting to integrate evidence for the potential inclusion of a kinaesthetic component of short-term and working memory (Wu & Coulson, 2014). These criticisms focus less on the hypothesised notion of the

Baddeley and Hitch (1974) structure and more on the general functioning of these components. Whatever role attention plays in the process, there is support for the separation of short-term and working memory according to this type of structure (Atkinson & Shiffrin, 1971; Baddeley & Hitch, 1974; Shah & Miyake, 1999). However, the visuo-spatial components of the modal models have not been as extensively studied as the phonological components. Therefore, although the same criticisms apply, less evidence has been published.

Regarding the structure of working memory, Baddeley (1996) attempted to provide further explanation for empirical findings through fractionation of the central executive. Therefore, the supervisory activating system and focused attention were incorporated into the central executive to account for the impact of deliberate control (Unsworth & Engle, 2005; Unsworth et al., 2013). The central executive has been the focus of criticisms of proposed tripartite modal structures for working memory. The stated needs for regulation via an attention-based supervisory activating system, apparent links with fluid intelligence (a complex system) and the requirement of deliberate control are important points in debates surrounding the validity of modal models and the structure of working memory in general (Conway et al., 2001; Cowan, 1999; Gray et al., 2017; Unsworth & Engle, 2005). Aside from the criticisms of the empirical findings applicable to the validity of the tripartite model, most criticism of the Baddeley and Hitch (1974, 1983) model has been directed towards the notion of the episodic buffer as an interface between short-term and long-term memory for information control and binding. Baddeley (2000) considers the episodic buffer to provide some explanation for findings of semantically based encoding, chunking and recall. However, the buffer has not been convincing in explaining findings regarding the role of fluid intelligence, attention and other components embedded in the complete functioning of working memory (Gooding, Isaac, & Mayes, 2005; Gray et al., 2017).

Baddeley (2000), in his discussion of the potential fractionation of working memory, outlined several problems in fitting empirical data neatly into the three-component model originally outlined by Baddeley and Hitch (1974, 1983). Issues such as studies of persons with impaired phonological short-term memories presenting dissociations between the auditory recall of digits versus visual recall of digits, presumed to be coded phonologically, were discussed in response to these critiques. Since findings did not appear to fit into the model of the phonological loop, further explanations were required. To provide a more comprehensive account of these contrary findings, the episodic buffer was added to the model of working memory. Researchers have argued for a neuroanatomical basis of the episodic buffer based on studies finding dissociations between immediate recall and central executive tasks, based on

the notion that the buffer contributes to online maintenance of integrated memory traces (Berlingeri et al., 2008; Koelsch et al., 2009). As Gooding et al. (2005) discuss, the hypothesised episodic buffer is both applicable and incongruent with their own and prior findings on amnesic patients. Although Baddeley (2003) does discuss some biological findings, the Baddeley and Hitch (1974, 1983) modal model was not designed to fit neatly into any specific theoretical neuroanatomical models.

Assuming the episodic buffer is conceptualised as a system for recognition, recall and binding, meta-analytical and experimental studies have provided some neuropsychological support for a separate system, particularly involving the inferior lateral parietal cortex, superior lateral cortex and frontal lobes (Berlingeri et al., 2008; Cabeza & Nyberg, 2000; Vilberg & Rugg, 2008). Active task switching, attention, self-regulation and selecting of appropriate central executive functions have all been ascribed to the episodic buffer alongside the central executive, potentially indicating the emergence of one more complex executive system rather than the formation of an interactive buffer (Hofmann, Schmeichel, & Baddeley, 2012). Similarly, the episodic buffer as a fluid system interacting with crystallised long-term memory systems is quite popular (Gooding et al., 2005). Several studies discussing the potential role(s) of the episodic buffer seemed to draw conclusions based on the interpretation of empirical findings pre-supposing or confirming the existence and role of this fluid system (e.g. Baddeley 1996, 2003, 2012; Baddeley, & Logie, 1999). Further research has formed the focus for specifically designed experiments producing findings of dissociations between immediate and delayed prose recall in amnesic patients with preserved executive function (Baddeley & Wilson, 2002). However, some of the results of studies regarding the episodic buffer have been incongruent, particularly following larger scale studies (cf. Gooding et al., 2005). Tasks such as prose recall and delayed prose recall are common in assessment of the episodic buffer as they are assumed to provide an indication of semantic coding and interaction with long term memory, a specifically referenced facet of this component of working memory. However, the nature of the episodic buffer is not yet well understood even though the existence of such a system seems to be widely accepted.

Criticism of most working memory models has produced overlapping neurobiological, empirical psychological and experimental evidence. This creates some confusion in the assessment of the components of these models, leading to a variety of confounding hypotheses regarding the nature of the components of working memory. Despite criticisms, the Baddeley and Hitch (1974, 1983) model of working memory provides a useful structure for the empirical testing of working memory as a compartmentalised system, particularly for the purposes of

formal assessment of function. The next chapter considers the formal assessment of working memory using a variety of task types, not all of which are linked to specific theoretical bases. Aside from debates surrounding the correctness of the modal view of working memory, the critiques discussed in this text have also focused on issues surrounding the nature of working memory as a cognitive process inseparable from other cognitive components such as intelligence which is briefly discussed in the following chapter in relation to working memory.

Chapter 3

Assessment of Working Memory and the Role of Intelligence

Assessment of the Components of Working Memory

Working memory tasks originated with tasks of short-term memory, notably, Miller's (1956) accounts of the magic number 7 in serial recall tasks and Broadbent's (1957) model based on similar digit or memory span findings. Later, the Baddeley and Hitch (1974, 1983) model of working memory, particularly the central executive and visuo-spatial components, was the basis for the development of many working memory tasks and used as an explanation of prior empirical findings. Later, anomalies were noted whereby digit span and short-term memory did not adequately account for other facets of remembering, for example, reading, comprehension and manipulation of information (Daneman & Carpenter, 1980). Components such as pragmatic, semantic and syntactic manipulation, alongside short-term recall, required more complex task types with specific functions.

Simple (short-term) memory is measured as a static, limited capacity system which is utilised for the storage and/or rehearsal of information whilst doing little else. These tasks may tap into phonological components such as sub-vocal rehearsal or visual stimuli. Additionally, motoric functions may be required in response methods. General memory span task types have been designed to assess the short-term memory system separately in much the same way as done by Miller (1956). Complex (working) memory, on the other hand, is an adaptive system requiring the keeping of task-relevant information accessible during the execution of a task. Tasks include components jointly tapping simple short-term memory storage and complex processing functions such as complex processing or directed attention. Peripheral functions also play a role, including motoric response times, sub-vocal rehearsal or verbalisation, visual acuity and attentional processes are also concomitant (Conway et al., 2005). Generally, short-term memory tasks, although separable to complex working memory tasks, are intrinsic to these complex tasks (Conway et al., 2005). Therefore, it is necessary to consider the scope of short-term memory when interpreting the findings of complex working memory tasks. Nevertheless, tasks have been designed for the measurement of the components of working memory whilst attempting to control for associated functions.

A wide variety of reliable and valid working memory tasks exist including counting span, operation span, reading span tasks, components of traditional intelligence tests, such as digit span and sequencing, as well as combinations of tasks measuring complex cognitive behaviours such as comprehension, reasoning and problem solving (Conway et al., 2005; Redick et al., 2012). Discussions of these tasks have frequently referred to the incidental role of executive attention as an underlying capacity in maintenance and retrieval of information,

as well as resistance to distractors (Redick et al., 2012). The original short-term memory span tasks such as serial recall, digit span, counting span and other visual immediate recall tasks are still applicable today. More complex working memory tasks have been developed and evolved to include various critical components and structures. Tasks requiring logic and reasoning alongside recall, such as reading span (Daneman & Carpenter, 1980) and operations span (Turner & Engle, 1989), were some of the first to assess complex working memory. In the case of reading span, a sentence is presented and the participant declares the logical accuracy of the sentence(s) whilst attempting to remember the final word for later recall. The operations span task is similar but replaces sentences with mathematical operations to eliminate potential semantic links which may aid memory functions. In both cases, the recall component is similar in structure to the original serial recall tasks presented by Miller (1956) whilst the addition of the processing component taps more complex, adaptive working memory functions. This example clearly illustrates the inherent nature of simple memory within complex (working) memory tasks.

Several studies have demonstrated that although short-term memory and working memory task performance are correlated, the coefficients are not sufficiently strong to suggest that the same construct is measured, although it is likely that a storage component is tapped in both. Conway et al. (2005) argued that working memory tasks reflect the functional importance of working memory but short-term memory span is inherent. This view was based on a review of empirical studies usually utilising reading and operation span tasks, dual component or basic recall task types (Conway et al., 2005; Oberauer, Süβ, Wilhelm, & Wittman, 2003; Unsworth & Spillers, 2010). Oberauer et al.'s (2003) study was particularly comprehensive, employing a repeated measures (test-retest) design as well as comparing memory and non-memory manipulation tasks. This design was intended to evaluate the two components of working memory (short-term memory and manipulation) in order to understand differences in variance. The researchers noted some shared variance between the two although, similarly to statements by Miller (1956) as well as Unsworth and Spillers (2010), the two were insufficiently related to assume a single component. Such studies utilising span and recall tasks appear to confirm the testability of working memory and short-term memory as separate though related constructs. The moderate correlations may indicate that an executively demanding secondary task is required for effective measurement of working memory span separately to short-term memory.

Factor analytic studies support the ability to assess executive working memory and short-term memory separately (Conway et al., 2005). Some early evidence indicated that

reading span tests (working memory involving storage and processing) better predict performance in reading comprehension than recall-based word span tests (short-term memory of words). This seems to indicate a difference in assessment of the two constructs, leading to the assumption that each is not only separable but also separately testable (Daneman & Carpenter, 1980). Similarly, complex span tasks demonstrate a relationship with attention tasks that have no obvious storage component, providing some evidence for the measurement of attention capacity as a component of working memory as hypothesised by theorists such as Redick et al. (2012), Unsworth and Spillers (2010), Oberauer et al. (2003) and Richardson (1996). However, this view is still tentative and subject to disagreement as to the role of attentional capacity (Buehner, Krumm, & Pick, 2005).

Further to the memory span tasks, other tasks have been developed to circumvent the inherent issues of "chunking" and mnemonic strategies such as linking to long term memory expertise which improves performance in word, reading and operations tasks (Chase & Simon, 1973; Conway et al., 2005). Tasks reliant on the phonological loop, for example, nonword recall, are intended to test short-term memory free from these limitations (Alloway, 2007). Nonword repetition is expounded as a measure of phonological loop functioning. Hypothetically, the act of repeating nonwords, linked to language acquisition and vocabulary development, is based on purely phonological learning as no semantic involvement is possible. As a result, this assessment of short-term memory is intended to measure the functioning of the phonological loop as a system of phonological short-term memory, in this case free from involvement of the episodic buffer (Alloway, 2007; Archibald & Gathercole, 2007; Gathercole, 2006; Santos, Bueno, & Gathercole, 2006). Correlational studies have demonstrated modest to lower correlations between assessments of the episodic buffer and nonword recall assessments (Alloway, Gathercole, Willis, & Adams, 2004).

Alloway et al.'s (2004) study sampled children with a less developed lexicon than the average adult, calling into question the generalisability of such a finding with varying findings comparing serial recall involving chunking in comparison to nonword recall. It seems to be generally accepted that phonological processing ability constrains performance on nonword repetition tasks (Bowey, 2006; Gathercole, 2006). Bowey (2006) noted that a variety of processing and storage processes for phonological information recall do exist. Although simple phonological recall is partially explained by these, children with specific language impairments appear to perform differently dependent upon the number of syllables included in the nonword. Based on analyses of the linguistic composition of the nonwords, Gathercole (2006), as well as Archibald and Gathercole (2007), both deduced that longer durations of stressed vowels may

facilitate clearer acoustic-phonetic processing. This view has also been espoused by Santos et al. (2006) in an experimental design. However, this hypothesis is problematic given that the phonological loop's activity in short term memory reproduction is assumed to depend on phonetic reflection during nonword tasks. Another point supported by experimental findings is that participants reflect phoneme strings presented along with other variations such as pitch without conscious awareness (Kappes, Baumgaertner, Peschke, & Wolfram, 2009). In general, it is possible that nonword recall, particularly single syllable nonwords, may not be as unique as originally considered and may be subject to the development of phonetic language acquisition and construction rules. Aside from phonological and visual span tasks, researchers have also focused on other tasks during neuropsychological and working memory studies.

In a review of a working memory imaging studies, Cabeza and Nyberg (2000) noted that the majority employed several primary types of task, namely, delayed response tasks, *N*-back tasks, self-ordered response tasks and/or problem-solving tasks. Delayed response tasks require the subject to be presented with one or more auditory or visual items and hold them in short-term memory prior to responding to a probe by indicating whether the item matches. This type of task requires maintenance operations and short-term memory as well as executively demanding operations such as attentional control and, sometimes, manipulation. *N*-back tasks require indication as to whether an item matches an item presented one, two or more items back in a series. These tasks involve both short-term maintenance and general updating of working memory utilising Baddeley and Hitch's (1974, 1983) visuo-spatial sketchpad, phonological loop and central executive functions. Self-ordered response tasks require motor or verbal responses in adherence with a rule and may require alteration of responses or avoidance of repetition. These tasks require continuous monitoring (central executive function) as well as inhibition of inappropriate responses. Problem solving tasks such as the Wisconsin Card Sorting Test and the Tower of London are commonly utilised as assessments of working memory, particularly executive and integrative functions (Conway et al. 2005). Although studies have used a variety of task types, with some tapping more memory components than others, generally only single tasks (either verbal or visuo-spatial) have been utilised in working memory studies in relation to alcohol.

Since most working memory studies utilise one task only, certain dissonances appear in findings regarding the impact of memory-impairing factors such as alcohol or lesions, as will be discussed in the next chapter of this text. Although a clear distinction between phonologically and visually based tasks does seem to exist, the type of task presented impacts the findings of lesion, experimental and imaging studies. Still, there has been a lack of clear

differentiation of the components of working memory despite distinct task types. The task selections for studies on the effects of alcohol specifically on working memory have also been subject to wide variation.

Generally, visuospatial tests of planning and executive function have been utilised when assessing the impact of alcohol on working memory. The Tower of London test and the Wisconsin Card Sorting Test have been amongst the most popular as they provide a more comprehensive assessment of working memory (Lyvers & Maltzman, 1991; Lyvers & Tobias-Webb, 2010; Weissenborn & Duka, 2003). Tasks such as the Acquired Spatial Association Task and Acquired Non-Spatial Association Task have been studied but do not clearly differentiate the modality of working memory assessed, although the visuo-spatial and executive components are most likely (Pihl et al., 2003). Studies utilising *N*-back tasks, digit span tasks of short-term memory and various other tasks assessing short-term memory, problem solving, manipulation of information, spatial tracking and other components of working memory have been subject to similar limitations (Cabeza & Nyberg, 2000), particularly the use of single modalities. The measurement of single modalities, or overly intertwined modalities, inhibits comparisons of studies on the impact of alcohol on short-term and working memory components. The original evolution of the components of working memory, and associated tasks, has not been considered when selecting tasks for assessing the impact of alcohol. Rather, studies have examined tasks measuring known components, or tasks measuring general, global functions.

Working memory tasks have evolved over time in association with the development of various theories in a dynamic process whereby theories have also evolved to accommodate empirical findings. Most tasks stress the functional importance of working memory systems, particularly with reference to the central executive component of the Baddeley and Hitch (1974, 1983) working memory model (Conway et al., 2005). These tasks distinguish between a static working memory system (storage and rehearsal) and a dynamic, adaptive system (the central executive) for task-relevant information accessible in memory (simple versus complex memory). However, differential performance changes on the different components following alcohol consumption has not been widely considered. At present, it appears that no published studies have compared different components of simple (short-term) and complex (working memory) verbal and visuospatial working memory in relation to alcohol consumption. Since working memory tasks cannot be completely deconstructed into their hypothesised components in a manner which clearly separates each function, investigations of working memory are often unable to limit themselves to one component only without tacit involvement from other

overarching functions. However, it has been possible to separate involvement of the central executive through use of short-term memory tasks such as phonological recall versus working or complex memory tasks such as *N*-back tasks. Therefore, the assessment chosen in an investigation of working memory is of importance to allow for an estimation of differential functioning of each hypothesised component under the experimental conditions. The Automated Working Memory Assessment (Alloway, 2007), examined in the present study, has utilised this division in task construction for a comprehensive assessment of short-term and working memory.

The Automated Working Memory Assessment

The Automated Working Memory Assessment (AWMA) is founded in Baddeley and Hitch's (1974, 1983) model of working memory and later revisions. The assessment was developed based on the conception of working memory as consisting of multiple components with co-ordinated activity via a central executive (Alloway, Gathercole, Kirkwood, & Elliott, 2008). Structural equation modelling produced evidence for four components within this assessment, analogous to those theorised by Baddeley and Hitch (1974, 1983) (Alloway, Gathercole, & Pickering, 2006). These components are verbal short-term memory (the phonological loop), verbal working memory, visuo-spatial short-term memory (the visuo-spatial sketchpad) and visuo-spatial working memory. Short-term memory is assessed via recall tasks while working memory is assessed via tasks requiring simultaneous storage and processing, primarily measured through stimulus evaluation. The pure processing component is used diagnostically while the composite working memory processing score is used as a general measure of working memory.

The verbal short-term memory component of the AWMA is comprised of three traditional short-term memory tasks which have been extensively utilised in memory span assessments, namely, Digit Recall, Word Recall and Nonword Recall. All three tasks require the recall of a series or sequence of items in the same order of presentation. The Digit Recall task requires the recall of single digits whilst Word Recall requires the recall of single real words. Therefore, the Nonword Recall task eliminates the potential for semantic interference. Digits recall tasks and the back-digit span are probably the oldest measures of short-term memory span (Richardson, 2007). As mentioned previously in discussions of Miller's (1956) work, participants generally exhibit a mean digit span of seven, but this figure has been demonstrated to increase following successive learning or improvement in mnemonic strategies over trials (Woods et al., 2011). Woods et al. (2011) discussed these findings in the

context of other tasks, concluding that, like the Automated Working Memory Assessment (Alloway, 2007) tasks requiring auditory presentation of the digits, the core components of the verbal short-term and working memory systems are being assessed. Therefore, it may be inferred that digit tasks utilising auditory presentation and verbal response, as used in the Automated Working Memory Assessment, are likely to provide clearer insight into verbal short-term memory functioning seated within Baddeley and Hitch's (1974, 1983) phonological loop structure. In addition to digit span tasks, word recall and nonword recall tasks are also hypothesised as being seated in the phonological loop.

Word recall tasks involve the auditory presentation of words followed by a verbal response method. A criticism of word span tasks has related to mnemonic strategies and the role of long-term memory (cf. Cowan, 1997), an important difference in comparison to nonword recall tasks. It is purported that performance on such tasks may be improved by using visualisation and memory strategies as well as the relation of items to be remembered to long-term memory retrieval pathways (Richardson, 2007; Woods et al., 2011). Although this may be true and has been discussed and referenced by several authors (e.g. Conway et al., 2005; Hulme & Maughan, 1991; Richardson, 2007), the AWMA circumvents this possibility by including a subtest measuring nonword recall for comparative purposes.

Nonword recall, the third component task for the measurement of verbal short-term memory, requires the participant to recall a series of nonsense words in the correct order. These span tasks are theoretically linked to Baddeley and Hitch's (1974, 1983) conception of the phonological loop component of working memory. Although various nonword tasks provide a similar regression slope when related to ability to word span tasks, the nonword tasks demonstrate a lower intercept which may be interpreted as indicating freedom from the long-term memory and mnemonic strategies which impact word span tasks (Hulme & Maughan, 1991). This freedom is a critical component of the contribution of the Alloway's (2007) Automated Working Memory Assessment Nonword Recall to general verbal short term memory comprehensive scores.

Verbal short-term memory is purported to rely on Baddeley and Hitch's (1974, 1983) phonological loop, requiring rehearsal of information during presentation and later recall. The Automated Working Memory Assessment has conceptualised this function within this framework (Alloway, 2007). These tasks generally result in an average of seven items being recalled by the individual (as originally found by Miller in his 1956 studies) as their design prevents the chunking of items together to increase span. Since no processing or complex understanding or assessment of the information is required, these assessments provide a true

composite of rehearsal, storage and recall only resulting in the short-term verbal memory score. Despite these efforts, it may be that individuals utilise visual mnemonic strategies to improve recall on such assessments (Paivio, 1991). Such strategies may even improve free recall or the recall of digits with which would not permit chunking or semantic associations (Rothen, Meier, & Ward, 2012). Similarly, the visuo-spatial sketchpad (visuo-spatial short-term memory) assessments seek to provide an indication of short-term memory functioning without interference from chunking strategies or long-term memory connections.

The visuo-spatial sketchpad component of the Baddeley and Hitch (1974, 1983) model is reflected in the AWMA's visuo-spatial short-term memory score, a composite of three assessments. The Dot Matrix assessment, a simple short-term visual memory task, requires the individual to recall the position of a series of red dots through motoric indication of recall (pointing). The Block Recall task works in similarly to the dot matrix assessment. A series of blocks are tapped by a moving arrow and the participant must reproduce the correct order or sequence. The moving arrow taps the tracking of spatial movements in addition to the positioning of the blocks as well as presenting a static set of positions encouraging the memory of sequences rather than briefly displayed positions. Lastly, the visuo-spatial tasks include the Mazes Memory assessment. A series of mazes (increasing in size and difficulty) are presented showing the "way out" from the centre by the presentation of a static red line. The individual must recall and trace this same path to respond to the item. This subtest combined spatial tracking with the presentation of a static stimulus, unlike the Dot Matrix and Block Recall subtests which require serial positioning skills.

Some neuropsychological evidence exists for the hypothesised fractionation of visual and spatial short-term memories, claiming a difference in processing requirements although these findings have not been consistent (Klauer & Zhao, 2004). In this case, the variety of tasks within the visuo-spatial short-term component of the AWMA, seem to incorporate both purely visual (Dot Matrix) and spatial (Mazes Memory) components, claiming to provide a comprehensive assessment of visuo-spatial short-term memory. However, it may be theoretically plausible that the introduction of both types of visual task could produce a discordant profile. Aside from the two forms of short-term memory assessed, the corresponding types of working memory are assessed through the introduction of a central executive component into short-term recall tasks.

Verbal working memory is assessed through the Listening Recall task, the Counting Recall task and the Backwards Digit task. The Listening Recall task is similar to the classical reading span task as utilised by Daneman and Carpenter (1980) whereby a sentence must be

judged as true or false and the final words recalled in the correct order. This produces a short-term memory task (word recall) with the addition of a processing component (evaluation of the sentences as a stimulus). The Backward Digit task has a manipulation component to the assessment of verbal recall (digits recall) with the addition of manipulation by reversing the sequence of the digits presented. However, some researchers have debated the possibility that the back-digits recall type tasks measure short-term memory rather than working memory. Some confirmatory factor analyses have indicated that these tasks may load to working memory for children and short-term memory for adults (St Clair-Thompson, 2010). Lastly, the verbal working memory component of the AWMA includes Counting Recall. The participant is required to count out the number of circles presented and later recall the numbers presented in sequential order. Although this test seems to incorporate a visual component, factor analytic studies, and empirical findings comparing normal children to those with reading impairments, have consistently demonstrated the relationship to other verbal working memory assessments (Alloway, 2007; Alloway et al., 2008).

The AWMA assesses working memory in the visuo-spatial domain using the Odd-one-out, Mister X and Spatial Recall working memory tasks. The Odd-one-out task requires the identification of the odd (different) shape in a row of three. At the end of the presentations, which increase in number with the progression of the test, the participant must recall the positions of the odd shapes out in the correct order via motoric pointing. This allows for a classical serial recall task along with the central executive component of identifying the odd shape out by processing the three shapes and evaluating the stimulus. The Mister X task requires the processing of the graphic and to identify whether one Mister X (little man) is holding the ball in the same or different hand to the other Mister X. Later, the sequential positions where the balls appeared are recalled from six possible positions via motoric response. This assessment is similar in structure to the Spatial Recall assessment where instead of identifying the same or different hand, the individual identifies whether a shape (which may be rotated) is the “same” or “opposite” of the shape to the left of it followed by recall of the position of a red dot from three possible positions. Both assessments require classical positional visual recall with a processing and stimulus evaluation component.

The AWMA tasks provide a clear indication of the various short-term and working memory functions which make up human cognition and memory expressed by the Baddeley and Hitch (1974, 1983) model. Incorporation of both short-term memory tasks and tasks requiring a central executive component allow for a more comprehensive comparison and understanding of memory than tasks confounding multiple factors (such as the Wisconsin Card

Sorting Test mentioned earlier). As a result, this assessment lends itself to identification of the more specific impact of alcohol on components of working memory, rather than on a single broad assessment of executive function alone. Although the assessment clearly targets short-term and working memory, another cognitive factor, intelligence, is known to be associated with both types of memory. This is true to the extent that some have described the combination of the two memory types as a global indicator of intelligence, specifically referencing the Baddeley and Hitch (1974) component measurement of working memory (Alloway & Gregory, 2013). Consequentially, to specify the impact of alcohol on short-term and working memory alone, one should briefly consider an intelligence component to ensure analyses free of a potentially confounding factor. However, this is challenging due to the multiple definitions of intelligence and methods of measurement.

The Relationship between Intelligence and Working Memory

Debate exists as to the relationship between working memory and intelligence. Whilst some authors argue the two are isomorphic, asserting that significant relationships exist between general fluid intelligence, short-term memory, working memory and processing speed (e.g. Conway, Cowan, Bunting, Therriault, & Minkoff, 2002), others contend that the two concepts are not identical although they are related and share some higher order cognitive functions which are conceptually and psychometrically separable (e.g. Ackerman, Beier, & Boyle, 2005). Many working memory tasks provide a measured working memory span which has been shown to be a stronger predictor of general intellectual ability than short term memory span (Conway et al., 2005), although individual variation exists (Alloway & Alloway, 2010). It is thought to be possible that working memory span, together with psychometrically measured intelligence, could reflect a more global aspect of intelligence than is measured by either alone (Alloway & Gregory, 2013). This global view of intelligence is inclusive of the *g* (general) factor discussed at length in the construction of intelligence tests.

The *g* factor (general factor) of intelligence reflects the common factor all cognitive ability tests measure, reflected by positive correlations between tests of all cognitive abilities and lower loadings on tests of simpler cognitive functions such as sensory discrimination and reaction times (Colom, Rebollo, Palacios, Juan-Espinosa, & Kyllonen, 2004). Meta-analyses have demonstrated strong correlations between various abilities and intelligence tests utilising verbal, numerical and spatial abilities. These include non-verbal assessments such Raven's Progressive Matrices and other assessments of the factor of intelligence (Ackerman et al., 2005). These analyses demonstrate a strong relationship between working memory measures

and cognitive abilities, but does not necessarily imply that *g* and working memory are identical constructs. However, the identified relationships confirm that some underlying commonalities are likely (Colom et al., 2004).

In their meta-analytical study, Ackerman et al. (2005) concluded that working memory and *g* are not, in fact, isomorphic, as evidenced by positive correlations of medium strength only, ranging between .200 and .700. The researchers also conclude that working memory tests with specific content, such as verbal content, are frequently strongly correlated with tests of fluid and general intelligence of the same content but do not always overlap with assessments reliant on different content reflecting the *g* factor. Therefore, working memory, *g* and *Gf* (general fluid intelligence involved in problem-solving, reasoning and other constructs) may be related but not necessarily convergent. Colom et al. (2004) argue that *g* is related to processing and *Gf* as a fundamental ability, but *g* is separate from working memory. Despite disparate theories, the evidence suggests that working memory may be related to intelligence. This indicates that control for intelligence variables in research studies of working memory is desirable. However, language barriers within the South African context may impact assessments of both *g* and *Gf*, suggesting preference to non-verbal assessments of intelligence which are more likely to be more culture and language fair. The Raven's Progressive Matrices attempt to measure *g* through non-verbal, culture fair and language fair stimuli.

Raven's Progressive Matrices (Standard Form)

Although verbal responses have been widely used as a tool for measuring intelligence, nonverbal assessments can provide a more rigorous, less biased assessment of cognitive ability free from verbal reasoning and confounds (McCallum, 2003). The Raven's Progressive Matrices (RPM) measures intelligence through eductive and reproductive ability. The assessment was designed to be easily administered and able to directly provide an interpretation of the general (*g*) factor of intelligence without interference from underlying skills, or latent variables, particularly verbal abilities (Raven & Raven, 2003). The concepts of eductive and reproductive ability originally stemmed from Spearman's formulations of fluid intelligence, assessing intelligence without depending on learned information, or abilities, particularly those related to traditional education (Raven, 2002).

Eductive ability refers to the ability to draw out information or make meaning based on schemata or complex stimuli. This ability refers to being able to educe (draw meaning from) correlates, generate schemata to handle complex events and logics and draw on logic to handle complex events (Raven, 1989). On the other hand, reproductive ability refers to the ability to

absorb, recall and reproduce explicit information. This ability refers to acquired information from which meaning is made through eductive ability (Raven, 1989). Problem solving through logical reasoning is seen as an indicator of general intelligence (*g*) and reasoning (Raven & Raven, 2003) and cooperates with reproductive ability despite only being loosely correlated (*r* = .500 in most cases) (Raven, 1989).

In the RPM, progressively difficult, logically linked figural items require the completion of designs as a measure of both deductive and eductive reasoning (Raven, 2000). Raven (1989) noted that activities requiring higher levels of eductive ability (fluid intelligence) are distinct from those requiring higher levels of reproductive ability (crystallised intelligence). Therefore, the Raven's Progressive Matrices is commonly utilised for educational, diagnostic and research purposes due to provision of a clear measurement paradigm for these factors in combination as a *g* factor (Raven, 2002). The instrument is particularly useful in multi-cultural contexts as it is language free and fair. However, the visuo-spatial nature implies that the results may be related to visuo-spatially based assessments of memory only. Additionally, capacity for clear and logical thinking may vary with the health of the individual, familiarity with testing, practice in testing situations and the experience of test-pressure. The incorporation of speededness, or time constraints, can also impact the findings of intelligence assessments. For this reason, the RPM is used without time constraints as these may influence the understanding of measured intelligence.

When attempting to understand cognitive capacity (rather than efficiency) an untimed mode of administration is preferable (Raven, Raven, & Court, 2000). Although some professions and selection processes may require both speed and efficiency, it is likely that the introduction of such a component could disadvantage persons who work slowly and carefully which is not ideal for experimental studies designed to control for true cognitive capacity. Research studies into cognitive capacity utilising the Raven's Progressive Matrices and other instruments have sparked debate as to whether working memory and intelligence are, in fact, the same construct (Ackerman et al., 2005). Therefore, control for intelligence, or general cognitive ability, in a study of factors impacting working memory is essential.

Chapter 4

Alcohol and Working Memory

The Impact of Alcohol on the Central Nervous System

Alcohol (ethyl alcohol, or ethanol) is a nervous system depressant despite not being a very potent drug, particularly at low dosages. Threshold effects for alcohol require exposure at high concentrations. These levels can also be reached quickly with repeated ingestion of a small amount of alcohol, but even low levels of exposure may impact the central nervous system (Davies, 2003). If consumption is not chronic, the effects on the central nervous system are reversible at moderate consumption levels, or dosages unlikely to lead to intoxication resulting in injurious medical consequences (Eckardt et al., 1998). The deficits observed are diverse and dependent on both physiological factors and dosages.

Consumption leading to low breath alcohol concentrations (BACs) may result in feelings of euphoria and associated disinhibition, followed by compromised motor movement, speech and cognition. Post-mortem studies suggest that excessive consumption results in changes in myelination and axonal integrity through some mechanism of neuronal change in various neurological regions (Fortier et al., 2014). It was originally believed that these deficits were the result of ethanol disrupting neuronal lipid bilayers (Davies, 2003; White, 2003). Lipid bilayers are membranes made up of two layers of lipid molecules surrounding neuronal cells which prevent ions and proteins from diffusing into areas in which they should not be. This disruption is complex, with alcohol interacting with a variety of functions and components of lipid bilayers including hydration, ionic permeability, pressure profiles and thickness (Ingólfsson & Andersen, 2011). Currently, evidence suggests that ethanol may bind with, and alter the function of, membrane bound ligand-gated ion channels (transmembrane channels allowing certain important ions such as calcium to pass through in response to a chemical messenger or ligand), voltage dependent ion channels (activated by changes in electrical membrane potentials and critical in neuronal function, particularly for muscle tissues) and specific proteins. This action produces an inhibitory action in some ligand-gated receptors and an excitatory action in others, thus altering the function of neurons and the central nervous system in general. This impact on ligand-gated ion channels is intrinsically linked to the function of several key receptors known to be heavily impacted by alcohol consumption, namely, gamma-aminobutyric acid type A (an inhibitory neurotransmitter also involved in muscle tone), 5-HT_3 (mood changes), *N*-methyl-D-aspartate (NMDA, which is linked to synaptic plasticity, learning and memory), neuronal niconitic synapses (cognitive function) and glycine receptors (mediation of inhibitory neurotransmission in the spinal cord and brain) (Crews, 1999; Davies, 2003; Oscar-Berman & Bowirrat, 2005). This cornucopia of excitatory,

inhibitory, emotional, cognitive, attentional and other physiological changes leads to the diverse cognitive effects seen following alcohol consumption. Findings demonstrating these deficits are moderated by the dosage of alcohol utilised in each research study as well as the population group studied in research utilising chronic alcoholics.

The Influence of Dosage

Although studies have investigated the influence of alcohol on working memory functions, subject to some of the previously mentioned limitations regarding task types and methodologies, few have investigated the influence of alcohol at a very low dose. Schweizer et al. (2006) focused their research on differential responses dependent upon positioning on the breath alcohol concentration curve and utilised a moderate to high dosage of alcohol at 0.65g/kg body weight with an aim of producing a measured peak BAC of 100mg/dL. The findings concluded that verbal and visuo-spatial processing, explicit memory and inhibition control were all impacted by this dosage of alcohol, in comparison to a placebo group, at different points on the curve. A study of the impact of alcohol on the Trail Making Test, an assessment of visuo-spatial working memory, processing speed and tracking, indicated that working memory was only impaired in a moderate alcohol dose condition with doses of 0.4g/kg producing no observable effect (Lechner, Day, Metrik, Leventhal, & Kahler, 2016).

Hoffman, Sklar and Nixon (2015) used the same assessment at low (40mg/dL of breath) and moderate (65mg/dL of breath) target doses. These researchers found that performance on set shifting, working memory and psychomotor factors were affected, but the effect was not statistically significantly different from a placebo group. In comparison, Lechner et al.'s (2015) study utilised a considerably lower target alcohol level reading (the equivalent of approximately 21mg/dL in breath alcohol values). The considerably lower dose may have impacted the differential findings. To better understand these findings, other research has examined the impact of alcohol on working memory and associated functions at varying doses. Hoffman et al. (2015) suggested that a bout of social drinking (~1-3 alcoholic beverages over the course of an hour) is unlikely to significantly hinder set-shifting or working memory performance, relative to a placebo, although certain cognitive functions are more likely to be impaired. Furthermore, Weissenborn and Duka (2003) administered 0.8g/kg (high dosage) of alcohol finding impairments on planning and task initiation while Lechner et al. (2015) found significant impairments in task switching following low-moderate and moderate doses (0.4g/kg and 0.8g/kg) of alcohol in comparison placebo. These examples of disparate findings of the effects of alcohol on complex executive functions may be due to moderating factors such as

decision making, intrinsic conditional/associative learning abilities used to develop performance strategies and normal drinking patterns (Finn et al., 1999; George et al., 2005; Weissenborn & Duka, 2003). Although the dosage of alcohol administered in the mentioned research protocols has typically been moderate, studies have varied within these levels although very few studies located utilised sub-clinical (very low) doses.

A general trend in the research is that higher dosages of alcohol lead to larger deficits in cognitive and motor functioning. However, this has not always been the case. For example, Casbon, Curtin, Lang and Patrick (2003) utilised a higher dose of alcohol equivalent to approximately four standard drinks consumed over a one hour period. The researchers found significant impairments in executive functions, specifically perseveration, the inability to alter task responses to adapt to new contingencies under high memory load demands (cf. Sklar & Nixon, 2013). As illustrated in the available research, studies have attempted to replicate the average social drinking quantities producing similar findings across the range of dosages used. However, even studies targeting low alcohol doses have focused on the achievement of certain breath alcohol levels or grams of alcohol per kilogram of body weight. Although from a statistical and practical context it is beneficial to consider the impact of alcohol on working memory at high doses, research has not considered sub-measurable doses. However, it is possible that these smaller doses also alter working memory function. Research experiments using low doses could give fuller understanding of the sensitivity of working memory to alcohol in a more nuanced approach with heightened ecological validity.

The Impact of Alcohol on Measured Working Memory

There is evidence that acute ingestion of alcohol affects behavioural, affective and cognitive functions including working memory processes (e.g. Field et al., 2010; Lyvers & Maltzman, 1991; Montgomery et al., 2011; Saults et al., 2007; Weissenborn & Duka, 2003). A range of findings have been produced utilising various experimental designs. These include general cognitive impairments, slowed reaction times, an increased number of "false alarms" in assessments requiring the response or response inhibition to specific changes in stimuli or contingencies, planning deficits, impaired mnemonic strategies and general impairments in load activation which is the keeping of information "online" for use in activities. However, many studies of the impact of alcohol on working memory lack methodological, experimental and theoretical congruency which makes comparisons of findings difficult.

The field of working memory is broad and various conceptually different tasks are available to measure the components of working memory. Conceptual differences relate to

varying definitions and constructions of working memory itself. As mentioned earlier in this review of literature, the construction and definition of the concept of working memory has an impact on the tasks selected for its measurement. For example, consideration of the Baddeley and Hitch (1974, 1983) model results in tasks focused on aspects of working memory such as executive function or spatial route memorisation (short-term visuospatial memory). By comparison, Cowan's (1997, 1999) embedded processes model results in a choice of tasks closely related to the role of attention in the memory processes. To measure the impact of alcohol on working memory, researchers are required to select appropriate components of the construct for measurement and further study. As a result, generalisable consensus about the impact of alcohol on working memory is difficult, if not impossible. Adding to this challenge, is the fact that working memory aspects are often confounded in task types. For example, tasks of executive function as per the Baddeley and Hitch (1974, 1983) model may be somewhat dependent on aspects such as task familiarity or expert performance as discussed by Ericsson and Kintsch (1995). These examples serve as warning to researchers attempting to generalise findings of multiple studies. However, the variety of theories also provides the opportunity to consider working memory and its associated tasks from a task-based orientation rather than a theoretical orientation. Theoretical orientation impacts task choice, interpretations and analyses amongst other components of research designs. Although tasks are fundamentally rooted in theoretical orientations, studies of working memory may also be task or activity focused and linked to theoretical orientation by extension rather than design. The present study aims to clarify some inconsistencies in existing research findings through attention to specific theoretical, and methodological, limitations in prior research as well as consideration of multiple, rather than a single, components of working memory through specific task choice. Through a task focused design, this research has attempted to separate well-known components of testable working memory to understand the impact of alcohol in terms of specific functions rather than broad activities.

Although it is well established that alcohol impairs cognition in a variety of ways, early studies were limited by an absence of appropriate tasks to precisely measure deficits (Hoaken, Giancola, & Pihl, 1997). Since the development of more sophisticated working memory tasks, studies of the effects of alcohol on specific working memory processes have produced mixed findings. This is partially since a wider range of tasks permits a greater variety of assessment foci. Although a specific working memory component (e.g. spatial working memory) may be assessed, the correlates and underlying functions of this component may differ considerably dependent upon the specific task chosen as well as the difficulty and sensitivity of the task in

question (Dougherty, Marsh, Moeller, Chokshi, & Rosen, 2000). Congruence in research is, therefore, difficult to achieve and the resultant assessment focuses on a global working memory construct rather than specific components.

Incongruences in research primarily exist because of the type of assessment utilised, differences in theoretical understanding of working memory, sampling criteria, research design and failure to consider timing of assessment following alcohol ingestion. More specific weaknesses exist due to physical sampling factors, a reliance on laboratory tasks (Montgomery et al., 2011), differential rates of rising or falling breath alcohol concentrations and failure to separate components of working memory during analysis (Saults et al., 2007). Aside from experimental protocols, examination of the effects of alcohol on measured working memory is subject to various confounding factors, including the fact that alcohol impacts several processes required for task completion. These include reaction times, visual processing, auditory processing, general memory, learning, speed and processing accuracy as well as motor processes (Grattan-Miscio & Vogel-Sprott, 2005). Studies in this area have also suffered from variations in the specific dosages of alcohol administered leading to potentially varying degrees of effect on the various cognitive functions studied (Hoffman et al., 2015; Lechner et al., 2015). In some studies, abilities have been found to be spared following alcohol consumption, for example, pattern recognition linked to increased temporal lobe activity, although comparisons to other studies are almost impossible due to the differing dosages administered (Hoaken et al., 1997; Lyvers & Tobias-Webb, 2010; Weissenborn & Duka, 2003).

Alcohol consumption related cognitive deficits have been observed on a variety of specific tasks. Task choice is a key factor to consider when interpreting alcohol-related cognitive change profiles as variations may impact the comparability of findings. Task choice in the assessment of the impact of alcohol on working memory has become an important topic due to the wide variety of general findings. Various task types have been used in the study of the acute impact of alcohol and effects of chronic consumption. These tasks have assessed a multitude of factors ranging from the impulsivity to general cognitive load to specific executive functions (e.g. Claus & Hendershot, 2015; Pihl et al., 2003; Ratti, Bo, Giardini, & Soragna, 2002). Although data is available for the effects of alcohol on some specific tasks or assessments (e.g. Finn et al., 1999 on Go-No-Go tasks; Weissenborn & Duka, 2003 on the Tower of London task and spatial reasoning tasks), studies have not compared the different modal definitions/concepts of short-term and working memory according to the Baddeley and Hitch Model (1974, 1983). Researchers have rather elected to focus on working memory as a

global construct although some studies have compared various task profiles (e.g. Saults et al., 2007).

General findings from a number of studies of alcohol on working memory tasks include impairments on general working memory processes, such as deficits in backward digit span tasks (Finn et al., 1999), slowed reaction times (Grattan-Miscio & Vogel-Sprott, 2005), false alarms in Go/No-Go tasks (Finn et al., 1999), planning and adaptability deficits (Lyvers & Maltzman, 1991; Montgomery et al., 2011), impaired memory for verbal and visual sequences, including mnemonic strategies (Saults et al., 2007), impaired spatial recognition (Weissenborn & Duka, 2003) and decreased general cognitive load activation (Paulus, Tapert, Pulido, & Schuckit, 2006). Other observed deficits have pointed to alterations in cognitive flexibility, speed of allocation of attention, information processing deficits, perseverative errors, planning deficits and deficits in the ability to suppress information (Ratti et al., 2002). These are widespread executive functions related to the frontal lobes discussed earlier in relation to alcohol and memory. Measurement of most of the mentioned functions has utilised tasks requiring executive functions. Although tasks are broadly separable into components of executive functions, the majority involve a spectrum of skills. However, certain task types focusing on specific cognitive functions have been used in the study of the impact of alcohol on working memory.

Attention and Inhibitory Control Tasks

Since strategic processing, storage, attention and impulsivity may all be affected by alcohol and are correlates of working memory, some studies have focused on the impact of alcohol on the potential for perseverative errors linked to processing, response inhibition, impulsivity and decision making (e.g. Claus & Hendershot, 2015; Dougherty et al., 2000; Finn et al., 1999). Some of these types of task also rely on contingency reversal, purportedly through executive control. These functions are performed through executive control and inhibitory control. Such tasks have been correlated with conditions such as attention deficit hyperactivity disorder which result in deficits in working memory (Finn et al., 1999). Correlated aspects such as performance monitoring, learning, associative learning, processing and short-term memory are also of importance and more prominent in some task types than others, particularly in executive functioning tasks.

Inhibitory control is known to be impacted by alcohol. This ability to inhibit responses is considered a core component of executive functioning, also present in set shifting and other working memory tasks (Shah & Miyake, 1999). It is possible to measure behavioural inhibition

somewhat separately from other components of executive function such as learning, association, general memory and more. However, tasks usually combine various executive processes to draw more general conclusions regarding the impact of alcohol, often requiring behavioural inhibition or initiation in response to stimuli. Go/No-Go tasks, for example, involve binary choice, usually through the pressing of one of two keys. Subjects must respond to one alternative and withhold choice for the other. An example of one version of this task is responding to every target except X, requiring the withdrawal of response for that target when 75% of other targets have elicited a response (Casey et al., 1997). Stop signal tasks rely on similar functions. Research has found significant impairment in response inhibition in Go/No-Go tasks as well as stop signal tasks following the administration of alcohol (Claus & Hendershot, 2015; Field et al., 2010; Finn et al., 1999). In addition to simple response inhibitions such as the Go/No-Go task, Claus and Hendershot (2015) reported a negative relationship between working memory performance and incorrect responses on the Go/No-Go task. This appears to indicate response inhibition is, as thought, a valid component of executive function which is impacted by alcohol consumption.

Building on the Go/No-Go task protocol, Finn et al. (1999) investigated the impact of alcohol on false alarm rates in relation to conditional associative learning and response inhibition in a more complex version of the task. Significant deficits were found in these functions following alcohol consumption. Conditional associative learning requires the learning and memorisation of arbitrary associations together with manipulation in working memory. Since it is known that Go/No-Go task types are also impaired, these results seem to point to a broader impairment in learning, association, response inhibition and general memory during alcohol intoxication. Research has shown decreased inhibitory control (relative to baseline) during administration of the continuous performance test (Schweizer et al., 2006) as well as the Conditional Associative Task (CAT) (Finn et al., 1999). Both assessments require inhibition of responses in response to visual stimuli and the learning of seemingly arbitrary associations. In this case, processing of a visual stimulus, initiation and inhibition of responses or actions is required. In these studies, more than one component of the working memory process is assessed. One aspect of these tasks is the underlying function present during response inhibitions, specifically the type of stimulus and whether the verbal or visuo-spatial domain is tapped.

Visuo-spatial Tasks

Broad neuropsychological deficits on visuo-spatial tasks have been reported in spatial recognition and planning during alcohol intoxication (Lechner et al., 2015; Pihl et al., 2003). Schweizer et al. (2006) reported significantly decreased function in visual-spatial working memory in comparison to a placebo group. In this case, the deficit held only on the declining limb of the blood alcohol concentration (BAC) curve. Additionally, the researchers note that their assessments of working memory reflected a below average working memory status in comparison to the normal adult. Studies have reported differing stimulant versus depressant effects of alcohol dependent upon time span and positioning on the BAC curvature during visuo-spatial working memory tasks. Acute intoxication during the ascending limb of the BAC curve has produced disproportionate impairment of executive functions based on visuo-spatial tasks of working memory, as reported in Oscar-Berman and Karinković's (2007) study. Researchers have also found significant deficits when comparing alcohol and placebo groups on short-term visual memory tasks, long-term visual memory tasks (marginal significance) and visuo-spatial working memory tasks. This appears to indicate a potential global impairment on tasks involving visuo-spatial short-term, long-term and working memory.

Pihl et al. (2003) confirmed this assumption for spatial tasks, finding significant ascending- versus descending-limb performance on an acquired spatial reasoning task but not a non-spatial task. The researchers hypothesised that the non-spatial task required left prefrontal activity whilst the spatial task required right prefrontal cortical function and, therefore, the two neuroanatomical areas may have been differently affected. In keeping with the right versus left hemisphere hypothesis in relation to spatial tasks, it is possible that the right hemisphere is more vulnerable to immediate alcohol related impairment than the left hemisphere, resulting in differential deficits following alcohol consumption (Oscar-Berman & Marinković, 2007). However, this does not confirm reasons for differences between ascending and descending limb performance. It does appear to be clear that spatial tasks are impacted by alcohol consumption, potentially being related to a more pervasive impact of alcohol on the right hemisphere performance, visuo-spatial and visual search tasks (Oscar-Berman & Marinković, 2007). As a result, researchers have studied a variety of visuo-spatial tasks to better understand the impact of alcohol on more specific areas.

Schweizer et al. (2006) found deficits following alcohol consumption on both short-term and working visual memory tasks. The short-term visual memory task used by Schweizer et al. (2006), a design memory task consisting of abstract line designs, was hypothesised to

require underlying working memory activity. The concept of underlying, or supportive, working memory activity during short-term memory tasks was also referred to in Baddeley and Hitch's (1974, 1983) discussion of the interactive modal model. This interaction highlights some of the challenges researchers face when attempting to study the impact of alcohol on working or short-term memory alone, necessitating the comparison of two assessments (one short-term and one working) for better distinction. Schweizer at al. (2006) also found deficits on long-term memory tasks where discrimination between target and non-target designs followed by a twenty-minute delay and recall is required. Lastly, the researchers demonstrated deficits of visuo-spatial working memory through an X's and O's trial. This task type requires memory for location while performing an additional distracter task followed by recall of positioning. This assessment of working memory required distracted processing rather than deliberate task related active processing. Distracted processing, the remembering of information despite distracting information may not provide a true indication of working memory in the sense of holding and manipulating task-specific information in memory, or active processing, as it requires recall following a continuous attention distracter task without active processing (Richardson, 2007).

Saults et al. (2007) investigated the impact of alcohol on visual and auditory memory utilising a similar task set to Schweizer et al. (2006). Visual working memory was assessed utilising visual array and visual sequencing tasks using a matrix of coloured squares. The visual array tasks required the immediate recall of an array of stimuli. In half the trials the memory and probe stimuli were identical whilst in the other half the stimuli differed. Participants were required to indicate whether the probe item had changed relative to the memory item. The visual stimulus task utilised a similar protocol with the exception that the pattern of coloured squares was presented one component at a time with memorisation of the full built array being required. Again, half the block of trials consisted of identical memory and probe items whilst the other half consisted of change items. Feedback was immediate through pressing of a "yes" or "no" key to signal response. In this case, the researchers found that acute intoxication had little effect on general working memory holding mechanism and the retention of concurrent items (visual array task) but did impact retention in visual sequencing tasks. In both cases, the impact of alcohol may have been moderated by positioning on the BAC curve. Saults et al. (2007) hypothesised that more research into timing of testing is required and that practice and fatigue effects may have impacted their findings. As opposed to some, more comprehensive, working memory assessments, the tasks utilised by Saults et al. (2007) were repetitive throughout each block representing additional time post consumption. Resultantly, rather than

a comprehensive variety of tasks impacting the findings, specific assessments were repeated. This may account for fewer differences exhibited in their final block of testing than in earlier blocks. However, this study was useful in being the first to consider working memory as a specifically modular model in relation to alcohol consumption excluding divided attention or sustained vigilance from the equation. Unfortunately, in the effort to remove confounding variables, Saults et al. (2007) were not able to assess short-term visual and working visual memories as comprehensive components separated from any further confounding factors, such as executive functions, which impacted the findings of some other studies. Additionally, the immediate test-retest paradigm utilised failed to control for baseline working memory and may have introduced practice effects. Nonetheless, the authors did conclude an impact of alcohol on visuo-spatial working memory, reflecting similar findings to those of Schweizer et al. (2006) for processes such as short-term memory and inhibition during distracted processing. Neither Saults et al. (2007), nor Schweizer et al. (2006), who utilised two groups of 10 young adults each, could discuss their findings in terms of intrapersonal variation or very complex working memory functions.

More complex tasks of visuo-spatial working memory include those involving visual tracking, conceptualisation and flexibility. Ratti et al. (2002) investigated the impact of alcohol on several assessments including the Trail Making Test. The task involves visual-motor tracking and visual conceptualisation. Participants are required to connect 25 consecutively numbered circles (task A) and a series of numbered and lettered circles alternating between the two sequences (task B). The scores obtained are based on the amount of time taken to complete task A, task B and the time difference between the two. In this case, the authors did not study the acute impact of alcohol but rather the impact of long-term alcohol consumption, known to produce similar deficits to acute intoxication. In Ratti et al.'s (2002) study, significant differences were found between matched controls and alcoholics between 37 and 64 years of age on task A, task B and the time difference between the two. Visual perception, perceptual motor speed, attention and visual tracking were all impaired. These findings are similar to those discussed previously involving other visual short-term and working memory tasks. Therefore, Ratti et al. (2002) debated the importance of the frontal lobe in all task types, including visuo-spatial tasks involving memory. This hypothesis is shared by other studies demonstrated widespread frontal lobe shrinkage related to alcohol consumption (Kubota et al., 2001). Unfortunately, in case of Ratti et al.'s (2002) study, the sample size was somewhat lacking and, although non-parametric statistics were utilised for analysis, the small sample of fifteen per group was likely to impact the findings. Despite these limitations, animal studies utilisation

visual and spatial memory tasks have produced similar findings following the administration of alcohol (Givens, Williams, & Gill, 2000; Santin, Rubio, Begega, & Arias, 2000). Other comprehensive studies have also utilised assessments of working memory in a more global format despite the potential for multiple variables confounding results.

Hoffman et al. (2015) utilised the same assessment (the Trail Making Test) as Ratti et al. (2002). The researchers subjected a relatively large (n = 62) sample of older participants (55 to 70 years of age) to acute intoxication or placebo rather than utilising chronic alcoholics. In this case participants were provided with one of two doses of alcohol ranging from peak breath alcohol concentrations of 40mg/dL or 65mg/dL or a placebo grouping. The authors failed to find differences between the placebo group and either of the dosage groups in performance on the Trail Making Test A, test B or a visual working memory assessment. Like other studies, intrapersonal variations were not accounted for, nor were baseline levels of performance. Lack of consideration of intrapersonal variation is important as working memory performance may vary at baseline dependent on age, the task used and even intelligence (Belleville, Peretz, & Malenfant, 1996; Salthouse, 1994). On the other hand, Lechner et al. (2015) demonstrated a significant difference between a high dose of alcohol and a baseline measurement on the Trail Making Test using a relatively large sample size of 41 participants without controlling for age. These authors utilised a baseline working memory assessment rather than a control group and comparisons with the placebo group demonstrated significant differences for those in the alcohol condition. Unfortunately, Lechner et al.'s (2015) study utilised a very general assessment of working memory processing speed and function (the Trail Making Test A and B) as this was the study's primary focus. However, this does not allow easy identification and comparison of the other components of memory affected as was the focus of the present research. Additionally, the study performed assessments nine days apart and then repeatedly following increasing dosages, potentially resulting in confounding practice effects (Anastasi & Urbina, 1997). Like other studies discussed, the authors reported a significant finding indicating a negative effect of alcohol on assessment performance in this visuo-spatial task. The contradictory findings demonstrated may have been the result of the differing dosages of alcohol, sample size differences, age of participants relating to age-influenced working memory decline or additional factors such as control for drinking habits. Despite these differences, a general conclusion may be drawn that alcohol consumption and chronic alcoholism do impact working memory in some manner. Although some studies, as discussed, did not report an impact on certain visuo-spatial tasks, the majority did report some effect regardless of sample size or age of the participants. More specificity in research (for example,

producing a sample with more specific age-ranges, consistent dosage, specific gender, etc.) may produce clearer findings which may be linked to other research in the future. Findings regarding the impact of alcohol on auditory short-term and working memory related to phonological loop and executive function have also been somewhat mixed.

Auditory-Verbal Tasks

Several common types of auditory-verbal task exist. These include tasks such as digit spans, nonword recall, word recall, sentence and operation spans, pseudo-word recall and more. The relationships between these types of tasks, alcohol and neuroanatomical structures have also been investigated, providing suggestions as to why alcohol may affect performance. Although alcohol does not appear to be correlated with hearing loss in the long term (Curhan, Eavey, Wang, Stampfer, & Curhan, 2015), researchers have observed immediate deficits on auditory processing tasks and working memory tasks reliant upon auditory functions (e.g. Crawford, 1997; Finn et al., 1999). However, no published works were located comparing auditory and visuo-spatial working or short-term memory functions following the administration of alcohol. Researchers such as Finn et al. (1999) did consider auditory working memory tasks (in this case, a backwards digit task), but the study's tasks and design were not sufficiently comprehensive to allow for comparison of short-term versus working memory components, nor for comparisons between auditory and visuo-spatial tasks. It is unknown as to whether alcohol is likely to impact auditory and verbal working memory tasks, supposedly centred in the phonological loop, differently from visuo-spatial working memory tasks since no comparative studies could be located.

Montgomery et al. (2011) investigated the impact of 0.4g/kg of alcohol on the Jansari-Agnew-Akesson-Murphy (JAAM) task. The task relies on auditory components to a certain extent since the individual is required to play the role of an office worker. Unfortunately, in this case, the auditory and executive functions, together with long-term memory, prior learning or training and prospective memory processes, are confounded and cannot be separated from one another. Since much of the task is reliant on auditory instructions and responses, a significant finding of a deficit is useful in understanding the interplay of working memory processes. However, it is not possible to conclude that auditory recall was specifically impacted since the task utilised relies on several functions. However, the researchers did conclude that working memory, prospective learning, long-term memory and auditory functions are affected by the administration of alcohol in a primarily female sample of young (18-25 years) persons. Other studies using similar tasks have produced incongruent findings.

A female population aged between 70 and 81 years old with moderate long-term alcohol consumption was used to investigate the long-term impact of alcohol consumption on cognitive status (Stampfer, Kang, Chen, Cherry, & Grodstein, 2005). This study consisted of a long-term test-retest design initially using a telephonic interview of cognitive status based on the Mini Mental Status Examination requiring learning and remembering items, the following of simple instructions (for example folding a piece of paper), replicating visual stimuli and the memorisation of items for delayed recall with interference. The authors further investigated the phenomenon utilising the East Boston Memory Test of verbal working memory and immediate, as well as delayed, verbal recall of word lists and sentences. The results indicated that women who drank moderately (less than 15.0g alcohol per day) tended to have better cognitive and verbal memory scores than those who did not drink. Heavier drinkers did not differ significantly from the moderate group. In fact, the findings indicated that women who drank 15.0g of alcohol per day or less had a 20% lower chance of cognitive impairment than those drinking no alcohol. It appears that moderate alcohol consumption over an extended period may, in fact, improve verbal working memory and recall for unknown reasons. However, like other studies discussed previously, when older samples are utilised, the variation between baseline measurements and intrapersonal factors may become significantly problematic when attempting to produce comparisons. However, although this study is useful in the understanding of a specific population over time, it does not describe the acute impact of alcohol on auditory memory and recall and has not been replicated. Additionally, neither Montgomery et al. (2011) nor Stampfer et al. (2005) studied the effects of alcohol on simpler components of auditory memory.

Researchers have considered the effects of alcohol on auditory components such as verbal fluency, verbal memory and long-term verbal memory but only a few have examined the acute effects of intoxication. Schweizer et al. (2006) studied the blood alcohol concentration curve in 20 male social drinkers with a mean age of 21.8 years drawn from a pool of university student volunteers. A variety of assessments were administered, including verbal and auditory memory assessments such as word discrimination (immediate and delayed) and a variety of visual tasks such as matching of symbols, location memorisation within a matrix and identifying matches and mismatches. The researchers noted a significant deficit in both short-term and long-term auditory/verbal memory tasks following alcohol consumption. Therefore, although Stampfer et al. (2005) did not find long-term deficits following general daily alcohol consumption in older women, alcohol may have an acute impact on auditory and verbal function in younger and older persons (cf. Hoffman et al., 2015). Unfortunately, few other

studies could be obtained for comparative purposes with the majority focusing on the deficits seen following chronic alcohol abuse (e.g. Crawford, 1997). While research has focused on global auditory components or specific auditory tasks, neither set of task types truly incorporated a specific executive functioning component in the verbal domain.

Fernandez-Serrano, Perez-Garcia, Rio-Valle and Verdejo-Garcia (2010) compared controls to persons under chronic use of alcohol and other substances on executive function with the inclusion of oral components. Tasks included letter-number sequencing, where the participant is required to reproduce a sequence of letters and numbers which have been mixed, as well as an oral trail making test which combined visuo-spatial and oral functions. In this assessment, the participants were required to visually search and orally respond. The researchers found that alcohol consumption levels produced only a significant trend on the letter-number sequencing assessment. No difference was observed between alcohol consumers and controls on the oral Trail Making Test. This study falls between Schweizer et al.'s (2006) findings of acute effects and Stampfer et al.'s (2005) study of moderate consumption. However, vastly different population groups were utilised in these studies. Nevertheless, it is plausible that chronic moderate consumption may not have a long-term impact whilst heavy consumption and acute effects may be present.

Further to these findings, Saults et al. (2007) also considered the acute effects of alcohol on neuropsychological function in younger social drinkers. These researchers utilised auditory array and sequencing tasks following acute, high dose consumption. The researchers noted that auditory arrays were more strongly affected than auditory sequences. Like Schweizer et al.'s (2006) findings, the researchers observed a significant effect following this dosage of alcohol which produced a mean BAC of 0.082 produced through administration of 0.72g of alcohol per kilogram of body weight. Therefore, the dosage for a 70kg man was approximately 50.4g, the equivalent of almost 200ml of 33% alcohol by volume. This dosage was considerably higher than those utilised in Schweizer et al.'s (2006) study and more significant effects were produced, although on different assessments. Therefore, it appears from the limited research that acute consumption alcohol may potentially impact auditory and verbal memory and working memory. The tasks studied thus far have utilised auditory responses of some type (e.g. verbal repetition or statement following manipulation). It is reasonable to assume that the output method following auditory input may have some impact on the findings presented. This factor contributes to challenges in comparing visuo-spatial and auditory tasks types. In the present research, the section on the Automated Memory Assessment outlined as the instrument of choice in this study, prevents visual tasks requiring motoric response only and verbal tasks

requiring verbal response early, thereby reducing potential confounding of output activities. However, in one case, the "Counting Recall" assessment, the participant is required to produce a verbal response following memorisation based on sub-vocal counting from a visual stimulus. This is quite unique, contributing to better understanding of the impact of stimulus and output types in the understanding of the impact of alcohol on the components of working memory.

Executive Functioning Tasks

The researchers mentioned in the previous sections conducted studies using an array of tasks covering a range of cognitive abilities. Since most working memory tasks used in studies on the impact of alcohol have been visuo-spatial with an executive component, the following short section will focus only on more specific executive function tasks and the skills surrounding them. As discussed in the section on auditory working memory, Montgomery et al. (2011) utilised the JAAM in an assessment of modest doses of alcohol on working memory. The task is utilised clinically and is known to be effective in identifying individuals with deficits in executive function following frontal lobe injuries (Jansari, Agnew, Akesson, & Murphy, 2004). The task measures broad executive functions such as planning, prioritisation and selection within a real-world simulation using both auditory-verbal and visual stimuli coupled with verbal and motor responses. Significant deficits were found at this level of alcohol dosage. This is probably the broadest task that has been utilised in alcohol related research but may not measure executive functions, or working memory processing, specifically enough.

Other researchers have utilised both a prospective memory task with similar virtual reality components alongside the Tower of London (ToL) assessment of executive function which requires a motoric response to executive planning based on visual stimuli (Leitz, Morgan, Bisby, Rendell, & Curran, 2009; Paraskevaides et al., 2010). A dosage of 0.6g/kg of alcohol was utilised in both Leitz et al.'s (2009) study and Paraskevaides et al.'s (2010) replication. Both studies found no effect of alcohol on either a virtual week-long simulation task or the ToL test. This is contrary to several other studies utilising similar task types. For example, Weissenborn and Duka (2003) studied the impact of 0.8g/kg of alcohol on a number of working memory tasks, including the ToL test. These researchers noted that a significant effect was produced when comparing alcohol to placebo and control. Additionally, subjects in the alcohol condition completed fewer trials in total, demonstrated reduced thinking time prior to initiating a movement (increased impulsivity) and demonstrated an increase in thinking time following a movement. The ToL test was designed with higher order planning in mind. The principle is that a variety of purposes compete for cognitive resources. Prioritisation is required

to utilise resources for a specific activity or purpose (schema-produced activation). Additionally, constant monitoring is required through general programming or planning by a schema attentional system. Since the focus is on planning movements and strategies rather than spatial understanding, executive functions in accordance with the Baddeley and Hitch (1974, 1983) model are the focus of the task (Shallice, 1982). In contrast, a similar test of planning and executive function, the Wisconsin Card Sorting Test (WCST), did display significant deficits after acute alcohol consumption.

Studies utilising the WCST have demonstrated deficits in performance following alcohol consumption. The WCST is also an assessment tapping into Baddeley and Hitch's (1974, 1983) central executive. The required skills include planning and response shifting based on visual stimuli and measured by the correct placement of the cards. Perseveration errors are noted as part of the paradigm and have been shown to be impacted by moderate and high doses of alcohol (Lyvers & Maltzman, 1991; Lyvers & Tobias-Webb, 2010). Perseveration refers to the continuing of behaviour despite a shift in contingencies. It is possible that such errors are linked to the effect of alcohol on impulsivity or through disinhibition, as discussed earlier. Since these complex cognitive functions involve competition between response inclinations as well as representation of cues, the links to executive control and alcohol induced deficits are clear. A component of tests utilising planning skills is response shifting. Some studies have investigated response shifting as executive function in relation to alcohol consumption.

Fernández-Serrano et al. (2009) discussed the impact of chronic substance consumption (including alcohol) on assessments of executive function. The researchers focused on the components of interference and set shifting. These tasks were the Stroop test, requiring inhibition of verbal responses to visual material, as well as the language-free alternative, namely, the five-digit test. These tasks tap into the Baddeley and Hitch (1974, 1983) central executive components of control whilst working with active memory. Fernández-Serrano et al. (2009) found that chronic alcohol consumption did not have significant predictive capacity in relation to performance on either auditory-verbal or visual-motor set-shifting or response inhibition tasks. However, Cromer, Cromer, Maruff and Snyder (2010) found deficits in error monitoring on a visual-motor task containing a form of response inhibition following alcohol consumption. These errors were made by violation of the specific rules of the task. Furthermore, Hoffman et al. (2015) considered the Trail Making Test as requiring visual-motor response inhibition. These authors concluded that the assessments were sensitive to the administration of alcohol. These, and prior, comparisons illustrate the potential advantages and

pitfalls of utilising studies on chronic alcoholics for comparative purposes providing further indication for experimental research in the field. Other paradigms have also investigated executive control through tasks related to manipulation of information, rather than planning and response inhibition.

Casbon et al. (2003) investigated the acute impact of alcohol on a variant of the auditory-verbal *N*-back task. This task requires concurrent storage and manipulation of information, clearly defined by Baddeley (1986) as a critical component of the central executive. In this case, the task required a component of response inhibition due to the presence of distracters. Therefore, this task can be studied in terms of the effect of alcohol on both error frequency and signal detection whilst controlling for memory load. Memory load is reflected in the number of presentations back the target appeared, considered to be two or more for high loads. The task requires the matching of the target and signalling the response when it appears. The researchers concluded that a modest dose of alcohol of approximately four standard drinks impacted the number of perseverative errors due to cognitive control deficits (i.e. deficits in executive function). Casbon et al. (2003) hypothesised that deficits are produced through cognitive decline rather than increases in impulsivity or reduction in response inhibition ability. This conclusion was reached based on the finding that heavy memory loads increased the likelihood of response inhibition errors specifically under alcohol conditions. Casbon et al.'s (2003) study therefore strengthens findings of executive function deficits following alcohol consumption made by authors such as Lyvers and Maltzman (1991) and, later, Lyvers and Tobias-Webb (2010) using different assessments. It is clear from experimental findings following acute doses of alcohol and on chronic alcoholics that mixed research exists as to the impact of alcohol on working memory. Since no studies have separated specific components for comparative purposes or carefully considered dosages, the findings provided could confound multiple variables without full understanding of a specific impact of alcohol. Mixed findings in the field point to a lack of congruence and a requirement for further experimental research.

Achieving Congruence: Reconciling Findings and Theoretical Contributions

Most studies of the effects of alcohol on working memory have relied on working memory tasks incorporating the central executive and executive function, without any attempt to separate simple short-term memory from complex working memory or processing. Specific understanding of how performance on working memory tasks is inhibited by alcohol consumption requires clarification of these potential confounding processes underpinning

working memory. An example of the lack of separation of short-term from working memory processes occurs in the study of the impact of alcohol on working memory, including research reporting the deficits found on the Tower of London Test (Saults et al., 2007). In this case, ingestion of alcohol may create deficits in executive function, visuo-spatial processing or both. This leads to a lack of clarity about the nature of the deficit. Similarly, increased perseverative errors found on Go/No-Go working memory tasks could reflect increased impulsivity due to alcohol consumption rather than inhibited working memory function (Weissenborn & Duka, 2003). Although tasks often confound a variety of cognitive processes, some common features in task choice in the study of the impact of alcohol on working memory exist, leading to further understanding of the processes affected.

A common feature of tasks used in studies which found deficits following alcohol consumption is the inherent requirement of cognitive control or central executive functions, such as in delayed responses, response inhibition, information processing activities such as the manipulation of information in memory and the shifting of contingencies (e.g. Casbon et al., 2003; Claus & Hendershot, 2015; Finn et al., 1999; Fernández-Serrano et al., 2010; Schweizer & Vogel-Sprott, 2008). However, if simple short-term memory and complex working memory task types, as well as the underlying working memory processing components, are not separated in studies of the impact of alcohol, it is impossible to identify changes in specific functions or activities. Lack of separation of these components, or the verbal and visuo-spatial domains, during the study of working memory in relation to alcohol has resulted in findings which report an array of deficits in executive processes such as rehearsal, manipulation, attention, planning and associated processes such as motoric functions, impulsivity, response times, inhibition, visual processing, auditory functions and other memory components (Saults et al., 2007). No published studies found in this literature review have attempted to isolate simple visuo-spatial or phonological short-term memory from complex working memory processes and most have been confounded by the presence of an array of executive processes during task completion. Resultantly, findings of deficits in working memory resulting from alcohol consumption have been incongruent and unable to identify which components of working memory are most affected or whether differential effects occur. This lack of clarity may be better understood when thinking of working memory as a function of task choice rather than theoretical orientation or executive function only. Nonetheless, comparisons across tasks are challenging, particularly when generalised (multi-component) tasks are utilised rather than more focused, specific activities.

Many studies which have noted deficits in working memory function following alcohol consumption have relied on single assessments of working memory as executive function, most notably tasks involving set switching (e.g. Wisconsin Card Sorting Test) (Lyvers & Maltzman, 1991) and planning (e.g. Tower of London task) (Montgomery et al., 2011; Weissenborn & Duka, 2003). Since a wide variety of working memory tasks exist, a variety of findings have been reported over the years. Lyvers and Maltzman (1991), following a dual run administration procedure, found alcohol to selectively increase perseverative errors on the Wisconsin Card Sorting Test but no increase in non-perseverative errors, potentially due to a selective depressant action on the prefrontal cortex. Similarly, tasks involving pattern recognition (temporal lobe) rather than planning (pre-frontal cortex) appear less affected by administration of alcohol, although both are assumed to rely, to a certain extent, on working memory (Weissenborn & Duka, 2003). In this case, the separation of simple short-term memory and complex working memory was not considered. Go/No-Go tasks, in which impulse control is an inherent component, are negatively impacted by the administration of alcohol as evidenced in increased false alarm rates. However, lower scores on measures of executive working memory and associative learning appear to moderate this relationship. Finn et al.'s (1999) study is a good example of the confounding of short-term, executive and learning processes which make the comparison of findings challenging. Components of other tasks such as task switching, covert rehearsal, strategic processing, imposition of a memory "chunk" load and complexity of task have produced differentially severe deficits following alcohol consumption and deficits appear to be dependent upon dosage of alcohol (Saults et al., 2007). It can be inferred from these findings that short-term memory deficits may serve a moderating function in the relationship between alcohol consumption and working memory deficits. Clearly, differing task choices have resulted in incongruent findings since components of working memory are neither separated nor compared when studying the impact of alcohol. In addition, studies have been unable to compare different task types for severity of deficit, partially due to the complexity inherent in each task and partially due to the lack of separation of short-term memory from working memory processes.

The issue of task type and number of tasks is important as many studies examining the impact of alcohol on working memory have focused on single working memory tasks, usually combining visuo-spatial and executive functions. Tasks of executive function in prior research have not considered the relevant sub-components making up performance such as phonological, spatial, short-term or working memory processing. According to the Baddeley and Hitch (1974, 1983) model, executive functions incorporate slave systems such as the visuo-

spatial sketchpad. Additional sensory and activity systems such as inhibition and cognitive flexibility are also inadvertently, and unavoidably, included in assessments (Shah & Miyake, 1999). As a result, reliance on separate control and experimental groupings does not always clearly account for intrapersonal differences in these components since deficits on a variety of tasks following alcohol consumption may be due to impact on a number of associated functions and processes in task performance. For example, deficits have been found on the Tower of London task assessing spatial working memory and planning, which additionally relies on motor movement sequencing, decision making and holding of solutions in memory (Saults et al., 2007). Therefore, it is unclear which processes suffered deficits. Similarly, perseverative errors on the Wisconsin Card Sorting Test may be partially due to generalised effects of alcohol, including decreased inhibition (Lyvers & Maltzman, 1991), decreased attention to salient cues (Steele & Josephs, 1990), decreased reaction times (Saults et al., 2007) or other motor impairments (Schweizer et al., 2006). General impairments on executive function and associated processes utilising the Acquired Spatial Association Task (right prefrontal cortical function) and Acquired Non-Spatial Association Task (left prefrontal cortical function) have also been found (Pihl et al., 2003). However, there is no clear indication as to the specifically affected processes or modalities and how these were impacted by alcohol on the intrapersonal level. The incorporation of a repeated measures (test-retest) design minimising practice effects in the present research is intended to better account for variances between subjects in these factors and within subjects following alcohol consumption.

The comparative impact of alcohol consumption on separate components of working memory, such as visuo-spatial or phonological, has not been examined, nor have the different impacts on working memory and short-term memory functions. This lack of comparability has primarily been the result of single task choices which incorporate a variety of functions combined under the banner of “working memory” as opposed to assessing component tasks measuring separate functions. Research focusing on separation of the components of working memory and comparing the deficits experienced by each of these components is necessary for a more complete understanding of the specific cognitive functions which are impaired following alcohol consumption.

Schweizer et al. (2006) attempted to control for these limitations by considering a separated short-term (immediate) and working (executive function) memory processes by including some short-term memory assessments such as the visual memorisation of three letters then a motoric response output of typing the letters after eighteen seconds (note earlier discussion on verbal memorisation from visual input with motoric output). However, even this

assessment confounds visuo-spatial processes, verbal processes derived by using letters, time-bound factors and motoric responses. The researchers presented findings of immediate deficits following alcohol consumption. These deficits were found in long-term verbal memory, information processing, declarative processing and delayed deficits in short-term visual memory, long-term visual memory and visual-spatial working memory. No deficits were found in short-term verbal memory or working memory as measured by holding three letters in memory whilst engaging in backward counting in a visuo-spatial format. These findings lend support to the possibility of differential impact on separate mechanisms of working memory. Although Schweizer et al.'s (2006) study was more comprehensive than most of the others reviewed, the results were still subject to many common limitations influencing the generalisability and comparability of their findings. Firstly, the sample included twenty male social drinkers of university age with ten persons assigned to each group (placebo and alcohol) thereby most probably not sufficiently accounting for baseline intrapersonal changes at a more stable level. Like the present research, intrapersonal factors were controlled for using repeated measures rather than group comparisons. However, different tasks were used for baseline and experimental conditions to avoid the necessary test-retest delay required for the avoidance of practice effects on a single assessment. Although the study was relatively comprehensive in its assessment of long-term memory, measures did not target working memory specifically, but rather focused on generalised tasks of short-term, long-term and visual-spatial memory, as well as related executive processes such as information processing and inhibitory control. Unfortunately, response types and input types (visual or auditory) were somewhat confounded in the different tasks, not allowing for speculation as to the precise nature of the deficits. Task types were also not considered separately whilst accounting for depreciated performance. These factors highlight the weaknesses identified in most studies assessing the impact of alcohol on working memory and contribute to the incomparability of findings and inability to draw generalisable conclusions across studies. As can be seen from the review of the literature, studies have not incorporated specific tasks measuring single components to compare components of working memory and short-term memory, resulting in incongruent findings. Discrepancies also exist due to differential experimental protocols regarding individual BAC (blood/breath alcohol concentration) and dosages administered. Many of the studies reviewed have utilised relatively high doses of alcohol to ensure an easily measurable effect. However, the ecological validity in such cases is questionable despite the valuable information provided. Additionally, as discussed in the earlier section dealing with dosage, the influence of alcohol appears to be differential at different dosage levels. This study has rather utilised a low dose

(approximate single standard drink) of alcohol more relevant to everyday drinking habits in the real world and frequent BAC readings to account for more specific within-person influences. In comparison to findings at higher dosages, low-dosage studies have produced less consistent findings.

Cognitive flexibility and adaptive thinking (central executive functions) appear impaired following any alcohol consumption, while logical decision making and interfacing between short term memory and long-term memory do not appear impaired at lower dosages of alcohol (<0.4 g/kg) (Montgomery et al., 2011). Lower doses of alcohol producing a BAC of around 0.01% have been found to impair central executive function tasks, such as the Jansari-Agnew-Akesson-Murphy task, which assesses executive function deficits in a simulated real-world environment (Montgomery et al., 2011). However, the JAAM is a highly complex task making the specific nature of the influence unknown. This reflects a similar dosage to that considered in this study, mirroring the need for study of the likely ecologically relevant effect although the present study debated the influence of alcohol on specific components rather than global functioning. Deficits following relatively low doses of alcohol have also been found on divided attention tasks and most related psychomotor tasks, such as Go/No-Go tasks, which incorporate inhibitory control (Field et al., 2010) and are often implicit in executive function assessments. However, Field et al. (2010) report much higher doses (around 0.08%) of alcohol being required for deficits in simple underlying functions such as reaction times.

Although some studies have compared dosages of alcohol on single tasks without comparisons of various components of working memory (e.g. Finn et al., 1999; Montgomery et al., 2011; Saults et al., 2007) and a few have included dosages and positioning on the BAC curve (e.g. Grattan-Miscio & Vogel-Sprott, 2005; Schweizer et al., 2006), the various facets involved in the impact of alcohol on working memory have not been combined into a comprehensive design. As a result, not only is there little consensus on how the individual components of working memory, as hypothesised by Baddeley and Hitch (1974, 1983), are affected, but there has also been insufficient consideration of dosage of alcohol and positioning on the BAC curve to elicit a comprehensive understanding of the phenomenon. Furthermore, traditional group comparison designs may be less than useful, particularly in studies with smaller sample sizes, due to the wide individual variations in the metabolism of alcohol and experience of intoxication.

Causes of the lack of comparability of findings in the literature, and the common limitations, include research design components such as lack of separation of short-term (simple) and working (complex) memory, utilisation of one task type only, adaptation effects,

inability to tap separate components of working memory through task choice (Saults et al., 2007), failure to consider the comparability of studies using differential dosages of alcohol (Montgomery et al., 2011), lack of consideration of positioning of the participant's positioning on the BAC curve (Schweizer et al., 2006), a failure to account for baseline levels of functioning and variation in a number of other factors including sample size, age, gender, frequency of alcohol intake, body mass index and average exercise levels (Montgomery et al., 2011; Saults et al., 2007; van Asselen et al., 2006). Furthermore, many studies in this field have not been sufficiently grounded in theoretical models, or the specified task choices subsumed in these models, to effectively separate components of working memory. Therefore, although studies have concluded that an effect is present, the mechanics and specifics are unknown.

Few of the studies reviewed have stipulated a specific model of working memory as the foundation for their choice of tasks, preferring to rely on complex working memory, or executive function, tasks incorporating central executive aspects. These include the Tower of London task and the Wisconsin Card Sorting Test (Weissenborn & Duka, 2003). In addition, studies have primarily relied on single tasks of short-term or working memory, often loosely linked to the Baddeley and Hitch (1974, 1983) central executive component. The issue of single versus multiple tasks relates to the seating of the components of working memory within the study. The object of interest has been performance on specific task types rather than the unravelling of the impact of alcohol on the specific components of that performance. The Automated Working Memory Assessment, incorporating twelve tasks and providing a score for the four facets of memory presented by Baddeley and Hitch (1974, 1983) provides more specific output for comparative purposes.

van Asselen et al. (2006) note the need for more effective sampling criteria during working memory studies in general, particularly studies of typically functioning working memory in comparison to alcohol induced deficits. However, due to practical difficulties this is not always possible. The present study attempts to control for variance through comprehensive repeated measures (test-retest) design and sufficient statistical consideration rather than attempting to increase sample size and compare experimental, control and placebo groups. Furthermore, extraneous sampling factors, such as body mass index, general health, average alcohol consumption and other individual differences also need to be considered during alcohol and working memory studies (Montgomery et al., 2011; Saults et al., 2007). Related to this, experimental groups have often demonstrated wide variations in age (Saults et al., 2007; Weissenborn & Duka, 2003), failure to match for gender (Montgomery et al., 2011), variations in drinking habits (Pihl et al., 2003), differing baseline vocabularies (typically

applicable for tasks measuring complex central executive function with phonological components) (Weissenborn & Duka, 2003) and, often, insufficient intrapersonal-biological pre-screening (Schweizer et al., 2006). These factors may impact the individual reaction to alcohol consumption and concomitant intoxication levels, as well as subjective experiences of intoxication. To address these critiques, the study reported here focused on comprehensive demographic information to ensure that individual variance is accounted for as far as possible. Rather than utilising a sample matching method, demographic variables are considered as part of the individual's response profile relating to both baseline assessment and experimental assessment outcomes. Demographics are one component utilised in the present research to ensure the reduction of error variance emanating from intrapersonal variation both over time and in initial measurement.

Existing research has relied primarily on only control and intoxicated experimental groups without consideration of the individual's potential to act as his own control in experimental design (Montgomery et al., 2011; Saults et al., 2007). Consequently, long-term repeated measures designs have generally not been utilised. In the few reported efforts to study working memory using repeated measures, difficulties with practice effects have emerged due to insufficient delays despite efforts to control these issues through manipulation of task types measuring similar constructs (e.g. Schweizer et al., 2006). The present study incorporates baseline function in a repeated measures design rather than utilising a separate control group to better control for within-person differences and eliminate practice effects as substantially as possible through a lengthy delay (e.g. Anastasi & Urbina, 1997 regarding practice effects and delays). The elimination of practice effects using a repeated measures (test-retest) design more thoroughly considers the true impact of alcohol on an individual level rather than introducing a potential source of variance by using a control group. Additionally, test-retest delay, as a variable, is incorporated into the study, ensuring clarity in the findings without this influence and guarding against individual retention leading to the practice effects usually observed. The design of the present study permits better understanding of the true impact of low dosages of alcohol on short-term and working memory functioning. In this way, comparisons can be drawn between baseline function and intoxicated test results of the same individuals.

The present research addresses the limitations of prior studies through comprehensive sampling, a focus on task choice and comparisons of working memory components grounded in a specific model of working memory, together with a consideration of the impact of low dosages. In addition to the theoretical contribution of the study, it may have practical and policy making benefits. These include increased understanding of deficits in working memory

following alcohol consumption, even once the individual has returned to a BAC level which allows him or her to legally operate a motor vehicle and other heavy equipment or machinery. Changes in working memory function because of different dosages of alcohol consumption may impact rational decision making and inhibitions, potentially leading to risky, or impaired, decisions as well as impulsivity in actions leading to medical and legal difficulties (Department of Mental Health and Substance Dependence: Noncommunicable Diseases and Mental Health Cluster, 2000; Parry, 2005). The findings may assist in specifying likely working memory deficits following consumption of a low dose of alcohol. As a result, probable cognitive processing outcomes and the practical implications may be predicted, even following a delay, minimal consumption or return to a legal BAC level. These findings may be extendable to the practical context in examining human behaviour following alcohol consumption and implementing risk management strategies and policies.

Subjective Intoxication

Subjective experiences of intoxication receives brief, if any, mention in studies. Very few studies have debated the influence of subjective experiences of intoxication when examining the impact of alcohol, particularly in low doses, on short-term and working memory. The reviewed studies have used placebo, control and experimental groups without measurement of subjective experiences of intoxication. This research selected the brief version of the Biphasic Alcohol Effects Scale as an effective measure of subjective experiences of intoxication via experiences of feeling stimulated or sedated to address the lack of consideration of this factor in other studies.

The Biphasic Alcohol Effects Scale (BAES), validated by Martin, Earleywine, Musty, Perrine and Swift (1993), utilises unipolar adjective ratings whereby the participants select the degree to which their current state of being is reflected by the word verbally presented. Due to the brief nature of this assessment, it was chosen for use in this research to evaluate subjective intoxication throughout the working memory assessments (see “Instruments” in Chapter 5). The Brief Biphasic Alcohol Effects Scale (B-BAES) version of the scale reduces the number of adjectives whilst still producing factors like those of the full version (Rueger & King, 2013). The B-BAES was extensively studied during a pilot process, producing findings congruent with measurements on the blood alcohol concentration curve for both American and Polish (translated) versions. Additionally, the content of the assessment appeared to mirror the observed behavioural and reported feelings of stimulation and sedation by the participants (Martin et al., 1993; Poprawa, 2015).

Subjective intoxication levels have not been given much consideration in studies of the impact of alcohol on working memory or cognitive function and, as a result, it is unclear as to whether subjective intoxication at low doses will have any significant impact if not correlated with blood alcohol readings due to low dosages. At high doses, expectancy of intoxication does not appear to determine negative outcomes in cognitive functions (Peterson, Rothfleisch, Zelazo, & Pihl, 1990). In understanding the impact of alcohol on both short-term and working memory it is important to understanding that although statistically different responses do exist between alcohol and placebo groups, subjective perceptions of stimulation or sedation may, or may not, play a role and were therefore considered in this research. Use of the B-BAES also allowed the present research to account for the effect of alcohol in the stimulated versus sedated domains, adding interest to the question of whether low doses produce a similar stimulating or sedating effect and under which circumstances these effects are present.

Objectives and Research Questions

The over-arching objective of the present study was an elaboration and expansion of current knowledge about the effects of alcohol on working memory. The present research separated and compared the components of short-term and working memory, namely, verbal short-term and working memory as well as non-verbal (visuo-spatial) short-term and working memory processing. The comparison of these components is unique in the research as although the studies referenced have considered the different components, as well as executive function as a whole, they have not been compared utilising a single sample with minimal practice effects via a repeated measures design with extensive delays between test sessions. Through these comparisons at a low dose of alcohol, the finer nuances of the impact of alcohol on specific components of working memory can be assessed and compared as opposed to an evaluation of the impact of alcohol on complex executive tasks as has previously been done.

In addition to the separation and comparison of components, the study examined a fuller spectrum of the constructs involved in the relationship between alcohol and memory. The objective of more complex analyses was to control for intrapersonal variables and changes not accounted for in most studies. The attempts to control these factors rested primarily in the cognisance of potential covariates or extraneous variables with the intention of fully examining each within-person factor in addition to comparisons between persons. To achieve this, several demographic variables known to moderate the impact of alcohol were considered. Age, in particular, was considered via methodological limitations in range and as a variable in itself. Throughout the experimental tasks, readings of blood alcohol concentration were examined

with the intention of minimising the effects of differing metabolic rates and differing levels of breath alcohol concentration. Additionally, subjective experiences of stimulation and sedation were measured throughout the assessments. This combination of objectives was intended to reduce challenges in comparing findings across studies through increased specificity in methodology as well as providing a more comprehensive understanding of the specific impact of alcohol on short-term and working memory.

The present study reduced sampling bias through use of specific criteria to reduce extraneous factors which have contributed to lack of comparability and unclear findings in similar pre-existing studies. Previous studies which attempted to control for baseline working memory function prior to alcohol dosing were limited by using multiple assessments either due to practice effects after only a brief delay, or due to the use of two related, but separate, instruments to remove practice effects. The present study utilised a single instrument with multiple component measures to control for baseline working memory whilst reducing practice effects by implementing a minimum of a three-week delay between the first and second assessment. This allowed for the impact of alcohol to be better understood at an individual level rather than in comparison to a separate control group while controlling for baseline intelligence. Furthermore, the analyses took cognisance of important demographic variables, such as age, which may have been linked to physiological responses to alcohol whilst also controlling for subjective responses. These objectives are operationalised in the following research questions:

1. Does alcohol affect short-term and working memory?
    a. Does alcohol affect performance on the verbal and visuo-spatial short-term and working memory tasks of the AWMA?
    b. Does alcohol affect verbal short-term or working memory differently from visuo-spatial short-term or visuo-spatial working memory?
    c. Does alcohol affect verbal short-term memory differently from verbal working memory?
    d. Does alcohol affect visuo-spatial short-term memory differently from visuo-spatial working memory?
    e. Does alcohol affect a specific type of assessment of short-term or working memory differently?
2. Is breath alcohol concentration level specifically related to different performance on short-term and working memory tasks?

3. Does subjective perception of stimulation or sedation at various points throughout the assessment, as measured by the Brief Biphasic Alcohol Effect Scale, affect performance on short-term and working memory tasks when breath alcohol concentration readings are controlled for?
4. Is control of intrapersonal and methodological covariates required when assessing the impact of alcohol on short-term and working memory?

In summary, the present study addressed the research questions as an initial point of departure in clarifying incongruences surrounding research in this area. The theoretical contribution is intended to be achieved through control of intrapersonal factors through comprehensive measurement of the potential additional variables breath alcohol concentration and subjective intoxication as well as repeated measures design and comprehensive component assessments. In addition, the research design is comprehensive, providing a critique of the previously favoured assessments and accounting for a variety of factors such as differences between components of working memory, dosage of alcohol and BAC curve values.

Chapter 5

Methods

The present study focused on methodological rigor in its methods. The sample population was drawn from the general population of males between 21 and 35 years of age in accordance with ethical restrictions imposed and the theoretical foundations for the measurement of working memory. Participants were required to complete a screening questionnaire, inclusive of demographic information, prior to participation (see Sample). Each participant underwent a baseline measurement on the Raven's Progressive Matrices (Standard Form) (Raven et al., 2000) and the Automated Working Memory Assessment's (AWMA) twelve subtests measuring verbal and visuo-spatial short-term and working memory (Alloway, 2007). Between 28 and 213 days (M = 87.38 days) later, the twelve AWMA subtest order of administration was randomized and conducted following a small dose (13.6g or 17.2ml) of alcohol. Prior to commencement of each subtest, the Brief Biphasic Alcohol Effects Scale (Martin et al., 1993; Rueger & King, 2013) was administered and breath alcohol concentration (BAC) readings were taken. Following data collection, correlational analyses and repeated measures analyses of (co)variance were carried out in order to assess the effects of alcohol on the twelve subtests. The upcoming sections provide details regarding the sampling, methods, instruments and analyses conducted.

Sample

Following ethical clearance for the study (see "Ethical Considerations"), participants were recruited via online advertisement and poster advertisement from a variety of locations. In compliance with the University of the Witwatersrand Human Research Ethics Committee restrictions, no advertising for students occurred within the University of the Witwatersrand, or targeted students from the university. No incentives were offered for participation. Participants were requested to complete the self-report screening survey questionnaire which collected information related to the exclusion criteria, as well as gathering demographic data including date of birth, home language, ethnicity, body weight, height, average exercise levels, whether the participant was employed in a high physical exertion job sector (for example, building), average alcohol consumption per week and the number of times, in the last two months, the participant consumed more than five standard drinks in a single session or day. The survey was available on the platform SurveyMonkey free of charge. Criteria for exclusion were based on self-reports of suspected or diagnosed substance abuse or mental/psychological disorders, chronic illness, the taking of medications known to interact with alcohol, the consumption of more than five standard drinks in a single session more than once within a two-week period or not regularly consuming alcohol (one drink at least once weekly). No females

were invited to participate due to the potential for harm in the event of unknown pregnancy. All potential participants were required to complete the online self-report questionnaire in full prior to invitation to participate. In some cases, the researcher was contacted directly by the participants, in which case the same questionnaire was administered verbally, or in person. Missing or incomplete responses were gathered via direct communication. All participants completed the questionnaire in full. A final sample of n = 16 males completed the full study.

Relatively small sample sizes are commonly produced in studies involving the administration of alcohol due to ethical, logistical and other requirements and challenges. Small sample sizes have not prohibited the production of useful findings similar to larger studies. Furthermore, additional care can be taken in mitigating this limitation via statistical methods for interpretation (see "Data Analyses"). Cromer et al. (2010) recruited a sample of n = 20 participants for a short-term, repeated measures (test-retest) study (two-day delay) which considered a wide variety of components of working memory and acute tolerance measures. In other studies of the impact of alcohol on working memory, Duka and Townshend (2004) managed to recruit a total of 24 university students (male and female) to participate in their single assessment group comparison study. Dougherty et al. (2000) were permitted to sample both men and women and recruited n = 20 participants divided into two groups, while Schweizer et al. (2006) recruited the same number of male students from a pool of university students.

Repeated measures designs are useful in mitigating the challenges presented by small sample sizes. In studies with larger sample sizes, similar levels of statistical results and findings were reported when compared to studies with smaller sample sizes (e.g. Finn, et al., 1999; Lechner et al., 2015, n = 41; Weissenborn & Duka, 2003, n = 95). These studies with larger sample sizes were permitted to recruit both men and women, reimburse participants and took considerable lengths of time with the assistance of research assistants and organisational funding as noted in the acknowledgements. Despite the larger sample sizes, similar levels of statistical significance were found when compared to studies with smaller samples such as that of Cromer et al. (2010) or Duka and Townshend (2004). Unfortunately, no studies reported effect sizes, or any simulation methods, for further comparison (see "Data Analyses" for comparison of the methods used in the present research). In contrast, the sample obtained in this research (n = 16) was assessed with a comprehensive test battery using a delayed repeated measures method. The following sections discuss the demographic and behavioural lifestyle activities composition of the sample. This section is followed by a psychometric description, and analysis in relation to the present sample, of the three assessments used, namely, the

Automated Working Memory Assessment (AWMA), Raven's Progressive Matrices (Standard Form) (RPM) and Brief Biphasic Alcohol Effects Scale (B-BAES). Information regarding the data normality, homogeneity and other statistics which were influential in the calculation of the inferential results, are discussed in the pre-analyses in Chapter 6, "Results".

Ethnicity and Home Language

Most of the participants (*n* = 11, 68.80%) were Black African, with the remainder being White/Caucasian (*n* = 4, 25%), and one participant being Indian (*n* = 1, 6.20%). Based on home language (English), the White and Indian ethnic groups were combined for descriptions and analyses due to low frequencies. Eight different home languages were reported, namely, Afrikaans (*n* = 1), English (*n* = 4), Sepedi (*n* = 5), Shona (*n* = 1), Sotho (*n* = 1), Swati (*n* = 1), isiXhosa (*n* = 1) and Zulu (*n* = 2). Due to the low frequencies, languages were classified into "African Origin" (Sepedi, Shona, Sotho, Swati, isiXhosa and Zulu) and "European Origin" (Afrikaans and English) creating a frequency categorisation of ~68.80% (*n* = 11) participants speaking languages of African origin and ~31.30% (*n* = 5) participants speaking language of European origin[1]. Table 1 shows the spread and proportions of the basic ethnic and language demographic information. Due to the repeated measures design of the study, this information was not included for further analyses but is reported for a full understanding of the sample characteristics.

Table 1

Demographic Characteristics of the Sample (n= 16)

		Frequency	Percentage
Ethnicity*	Black African	11	68.80
	Indian	1	6.30
	White	4	25.00
Home Language*	Afrikaans	1	6.30
	English	4	25.00
	Shona	1	6.30
	Sepedi	5	31.30
	Sotho	1	6.30
	Swati	1	6.30
	Xhosa	1	6.30
	Zulu	2	12.50
Language Category	African Origin	11	68.80
	European Origin	5	31.30

[1] Rounding error noted in the percentage calculations to 1 decimal point

Note. Rounding error in percentage calculations to 1 decimal point

Age

Participant ages ranged between 21.16 and 31.13 years (M = 25.72 years, SD = 3.28 years, SE_M = 0.82 years) at the time of the first assessment. The low standard error of the mean provides some confidence in the representativeness of the ages of the sample drawn within the cut off markers. The use of cut off ages (*min* = 21 years, *max* = 35 years) truncated the parameters and potential range of the age characteristic of the sample to keep the sample homogenous for the purposes of analysis and potential changes in physiological and memory factors. The calculated variance (*var* = 10.75) reflected the range of the distribution (*range* = 9.97). The dispersion from the mean (SD = 3.28), coupled with the variance statistic, suggests a reasonable distribution of points around the mean within the specified age range. Table 2 and Figure 1 show the descriptive statistics regarding age, including means at the 95% confidence interval (CI). The upper and lower mean at the 95% confidence interval encompass a substantial proportion of the sample ages, further demonstrating a reasonable spread.

Table 2

Spread of Sample Ages (n = 16)

	Min	*Max*	*I-Q Range*	*M*	SE_M	$M_{tr(5)}$	*95% CI$_{lower}$*	*95% CI$_{Upper}$*	*Median*	*Var*	*SD*
Age (Years)	21.16	31.13	5.88	25.72	0.82	25.67	23.97	27.46	25.61	10.75	3.28

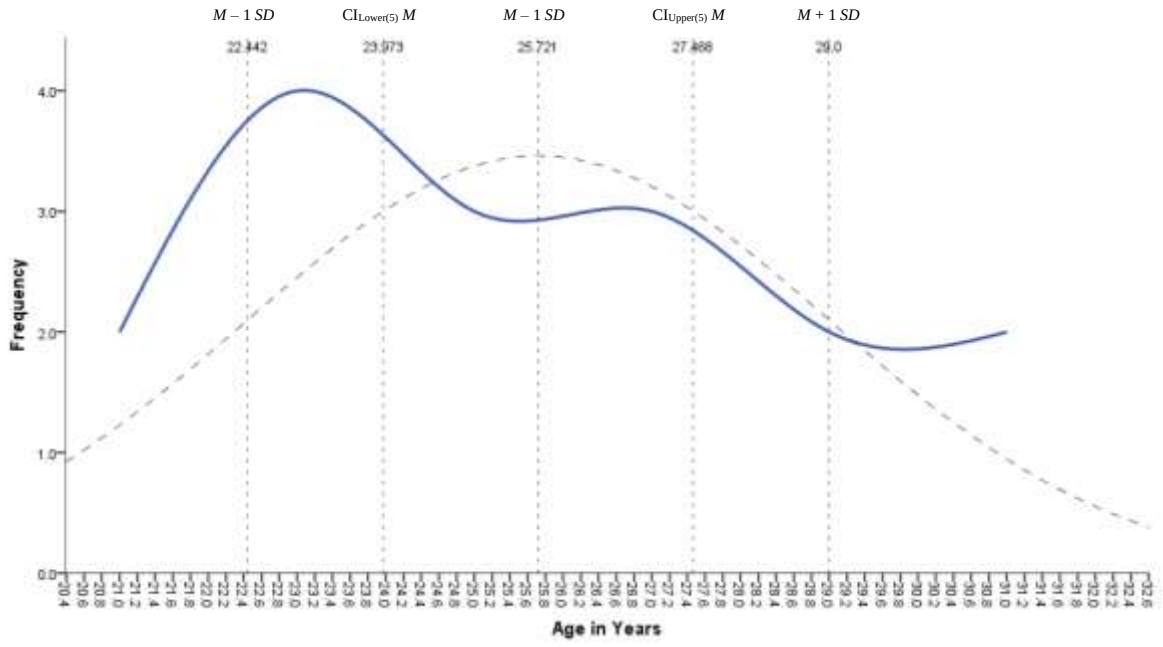


Figure 1. Sample Ages Distribution (n = 16)

To understand this information in context, and to account for further characteristics which may impact specific alcohol metabolism, physiological characteristics relating to the physical health of the participants were also examined. The influence of participant age was included in these comparisons and examination of interrelationships.

Health-related Physiological Characteristics

To assess basic health/physiological components which may impact the metabolism of alcohol, weight and height were reported to calculated body mass index (BMI). Participants measured via self-report at a mean height of 176.38 cm (*SD* = 10.47 cm) and an average weight of 70.56 kg (*SD* = 13.26 kg). This resulted in an average body mass index (BMI), defined as weight in kilograms divided by the square of height in metres, of 22.60 points (*SD* = 3.19 points) which is just outside the commonly known normal range of 18-22 points. Categorically, 81.30% (*n* = 13) of the sample were classified as "Normal weight" whilst the remainder of the participants were classified as "Overweight" (*n* = 3). The general participant physiological characteristics are shown in Table 3.

Table 3

Descriptive Statistics for Height, Weight and Body Mass Index (n = 16)

	Range			*Central Tendency*						*Dispersion*	
	Min	*Max*	*I-Q Range*	*M*	SE_M	$M_{tr(5)}$	*95% CI_{lower}*	*95% CI_{Upper}*	*Median*	*Var*	*SD*
Height (cm)	160	195	10	176.38	2.62	176.25	170.79	181.96	178.50	109.72	10.48
Weight (kg)	54	92	26.50	70.56	3.32	70.29	63.49	77.63	65.00	175.86	13.26
BMI (Points)	18.51	29.39	4.46	22.60	0.80	22.45	20.90	24.30	21.79	10.14	3.19

Body mass index should be understood in the context of exercise levels and concomitant muscle masses, general health and metabolism. The greater proportion of participants reported exercising once or twice a week (*n* = 7, 43.80%) and equal numbers of participants (*n* = 3, 18.80%) reported exercising either no times per week, three or four times per week or more than four times per week. Only one participant reported being employed in a physically intensive job sector (truck loading/unloading) but did not describe the work as feeling physically strenuous and was not identified as an outlier in terms of other variables. Table 4 shows the sample characteristics for BMI and exercise levels.

Table 4

Body Mass Index (BMI) and Exercise Activity Sample Characteristics (n = 16)

		n	%
BMI Category	Normal	13	81.30
	Overweight	3	18.80
Exercise Sessions Per Week	0	3	18.80
	1-2	7	43.80
	3-4	3	18.80
	4+	3	18.80

Note. Percentages are approximate due to rounding error

The following figures represent the variance and dispersion of general health data in the sample. The sample height to weight ratios were quite variable, indicating a spread reflecting the dispersion noted in Table 3 for BMI (*var* = 10.14, *SD* = 3.19) and reflected in Figures 2 and 3. Examined separately, Figure 2, the participant's weight to height ratios in comparison to the means, illustrates an upward trend.

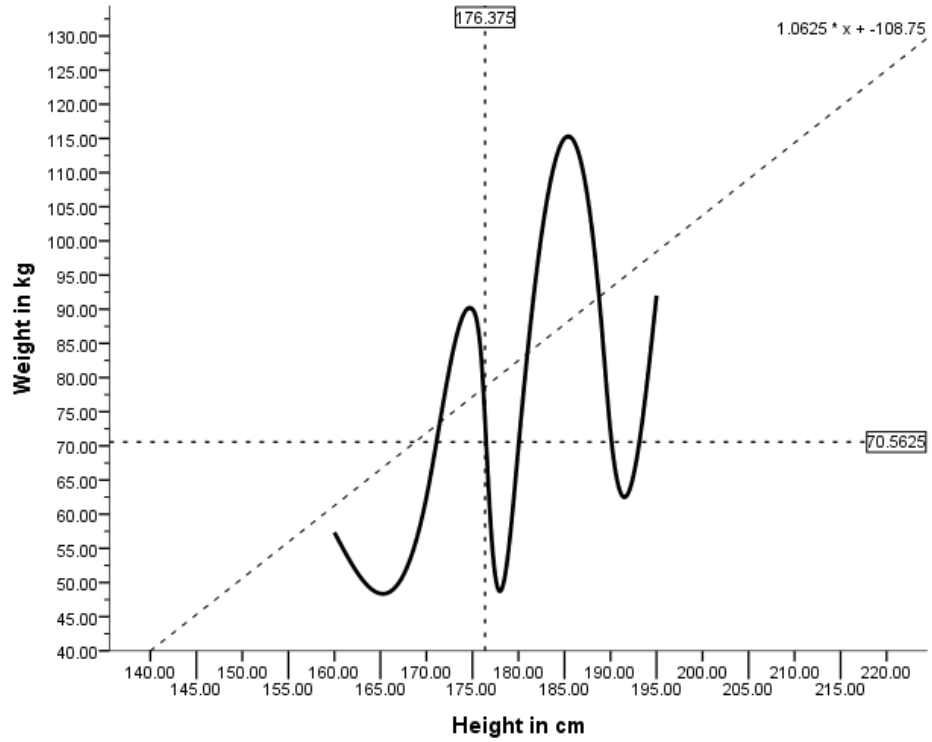


Figure 2. Height (cm) to weight (kg) ratios (*n* = 16)

Body Mass Index is a direct reflection of the height-weight ratio of each participant and most participants fell towards the allocated normal range of 18-22 points as shown in Figure 3.

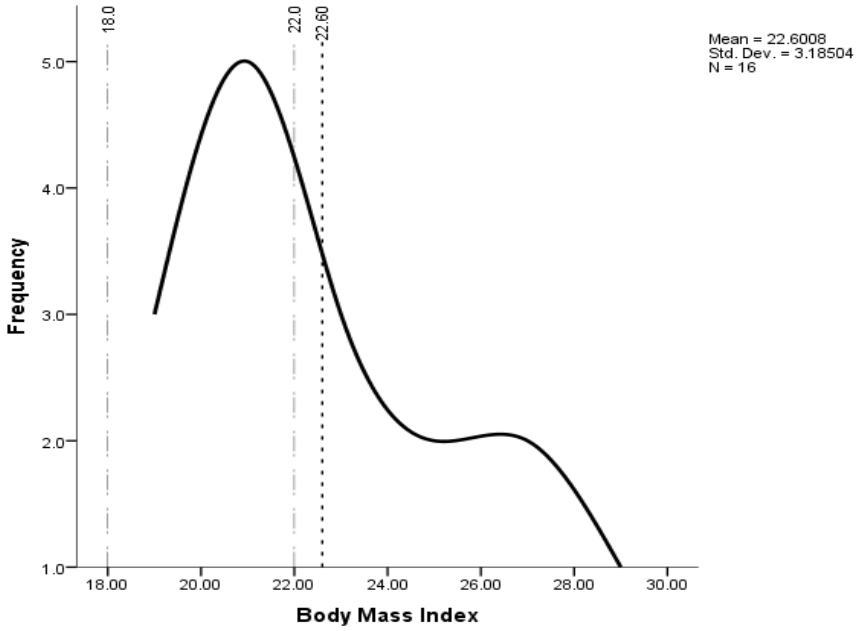


Figure 3. Body Mass Index (BMI) (*n* = 16)

Participants who exercised once or twice a week had lower calculated BMI points than those who did not habitually exercise. Exercise levels of more than 1-2 sessions per week did not seem to impact BMI points and weight in kilograms, although a slight upward trend was observed. However, reporting zero exercise sessions per week was associated with higher weight and BMI values. Therefore, exercise levels appeared to stabilise the BMI relationship. This information is depicted in Figure 4 and in more depth in Figure 5. The potential significance of these relationships is discussed further in Chapter 6, "Results".

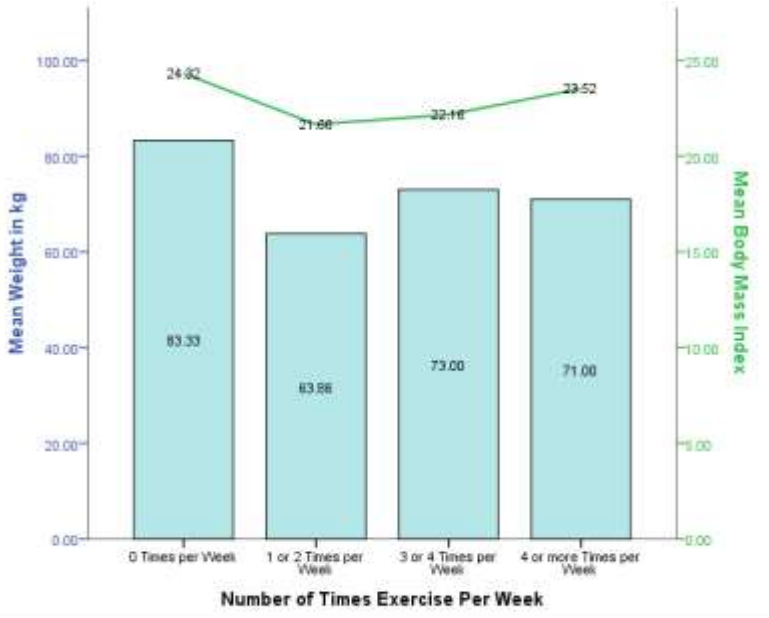


Figure 4. Exercise in relation to BMI and Weight (*n* = 16)

The relationship between weight in kilograms and BMI points was examined separately for different frequencies of weekly exercise sessions. Figure 5 shows a general upward trend for weight in relation to exercise, with those who did no exercise demonstrating greater weights and, therefore, greater body mass indices. The data for persons exercising appears to stabilise as the amount of exercise increases. The increase in BMI as weight increased is closest to the hypothetical reference line for persons exercising zero times per week or 1-2 times per week.

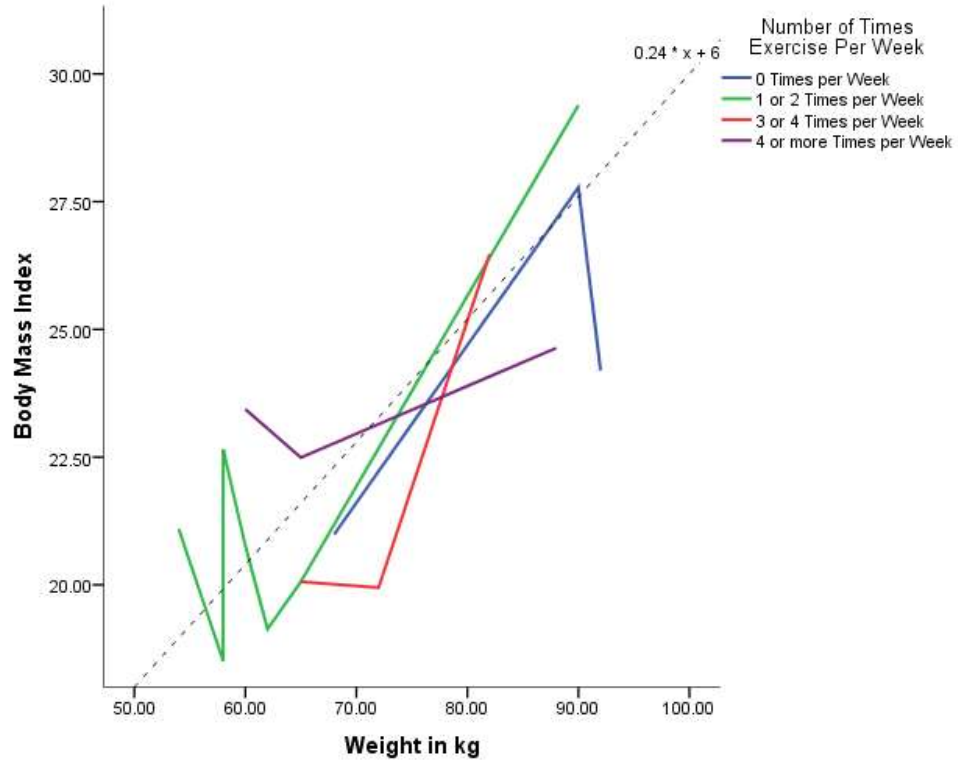


Figure 5. Weight-BMI in relation to average weekly exercise (*n*= 16)

A summative reporting of the general health and lifestyle relationships can be viewed in Table 5 while figure six illustrates the more complex relationship between the physiological and exercise variables.

Table 5

Health related physiological characteristics in relation to exercise levels (n = 16)

	0 Times per Week			*1-2 Times per Week*			*3-4 Times per Week*			*4+ Times per Week*		
	M	*Var*	*SD*	*M*	*Var*	*SD*	*M*	*Var*	*SD*	*M*	*Var*	*SD*
Age	28.18	7.49	2.74	24.67	12.18	3.49	24.99	6.49	2.55	26.44	15.65	3.96
Height	185.00	75.00	8.66	171.71	75.57	8.69	182.00	52.00	7.21	173.00	217.00	14.73
Weight	83.33	177.33	13.32	63.86	144.81	12.03	73.00	73.00	8.54	71.00	223.00	14.93
BMI	24.32	11.54	3.40	21.66	13.44	3.67	22.16	13.95	3.74	23.52	1.15	1.07

Figure 6, below, shows the respective weights (blue squares) and heights (green circles) marked by age at various points on the BMI spectrum divided by reported exercise levels. The distance between each marker is an indicator of the closeness of the adjusted relative relationship/ratio between weight and height. Persons in the four or more times per week exercise group demonstrated short distances between the two points but tended towards the "overweight" level of BMI (towards the inside of the four quadrants). By contrast, persons in the 1-2 exercise sessions per week group all tended towards the "normal" portion of the BMI spectrum.

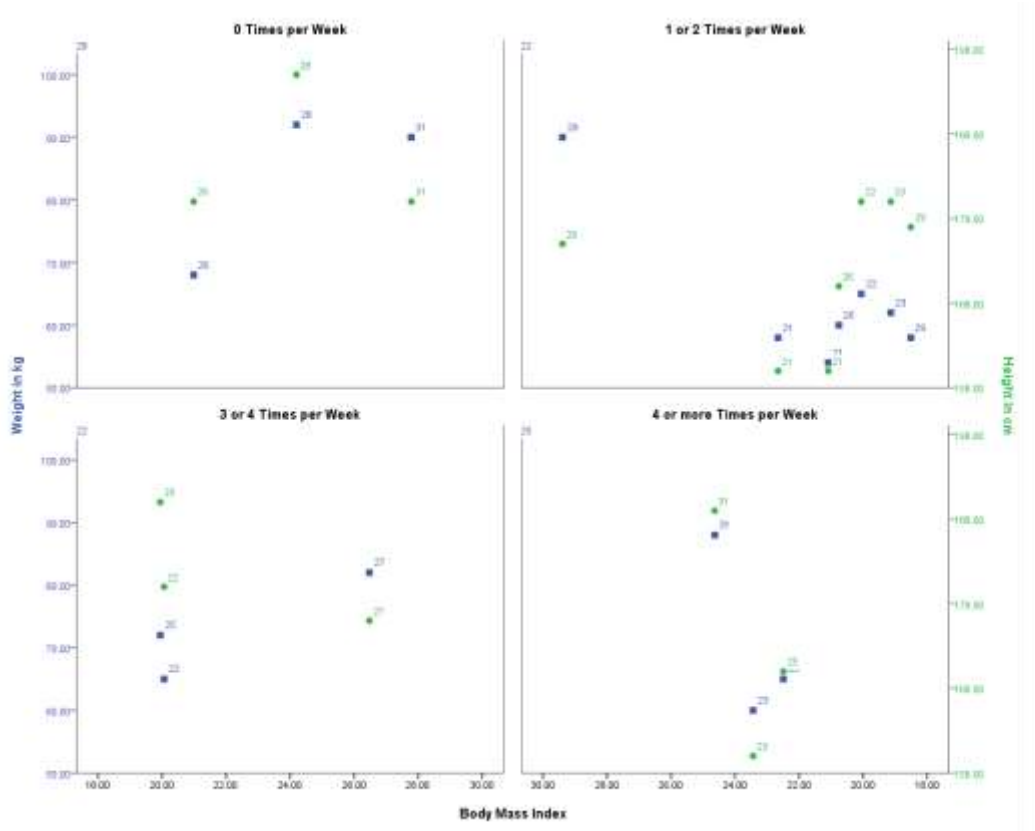


Figure 6. Graphical representation of health and lifestyle characteristics in relation to average exercise levels (n = 16)

Table 5 and Figure 6 showed a moderate dispersion for most of the exercise categories. Generally, the weight points are lower and seated towards the outsides of the full graph reflecting lower BMI's for the groups which reported exercising. If the 0 times per week category is disregarded and the increased heights in the 3-4 times per week group are accounted for, a progressive upward trend can be visualised in body mass index. The 0 times per week group had a higher mean age (28.18 years) and greater height. However, this group still reported a mean weight (83.33 kg) higher than that of the 3-4 times per week group who demonstrated a similar mean height and standard deviation (M = 182.00 cm, SD = 7.21 cm).

This type of information may have some impact on the metabolism of alcohol and baseline working memory function. However, the repeated measures design should have controlled for these differences. These considerations were taken forward in the examination of drinking behaviours. The general alcohol consumption and lifestyle behaviours are examined here as a precursor to the data analyses.

Weekly Alcohol Consumption Behaviour

Weekly alcohol consumption (drinking) behaviour was examined categorically. Categorical measurement was chosen to account for inevitable deviations. Participants were asked to consider their average, "normal", drinking behaviour and to disregard the influence of high consumption occasions occurring only every two or more weeks. Four participants (25.00%) reported consuming one or two standard units of alcohol during an average week whilst six (37.50%) reported consumption of three or four units. A further four (25.00%) consumed five or six units and the remaining two (12.50%) consumed seven or more units in this time frame. Binge drinking, as an exclusion criterion, required the repeated consumption of more than five units in a single session within two weeks of each other over at least two occasions during a two-month period. Although some participants met the requirements of more than five units on a single occasion, these occasions were separated by delays of more than two weeks over the two-month period, which was clarified during the first assessment session and permitted their inclusion in the study. Two participants (12.50%) did not report any occasions of such consumption whilst eight participants (50.00%) reported such activity once or twice in the past two months and the remaining six (37.50%) reported consuming more than five units on one occasion three or four times in the past two months with at least two-week delays between occasions.

General drinking behaviour is important for placing the obtained breath alcohol concentration readings and relative/subjective effects of intoxication in context. As discussed earlier, the impact of alcohol on cognitive functions should be considered in terms of how habituated the individual is to the substance. Consequently, drinking behaviour was examined in relation to some of the demographic variables. The frequency spread of average weekly alcohol consumption, as per Table 6 and Figure 7, below, produced sufficient variation with approximately equal distributions across each group.

Table 6

Weekly Alcohol Consumption (Drinking) Behaviour (n = 16)

	Number units	Frequency	Percentage
Number of standard units of alcohol consumed per week	1-2	4	25.00
	3-4	6	37.50
	5-6	4	25.00
	7+	2	12.50

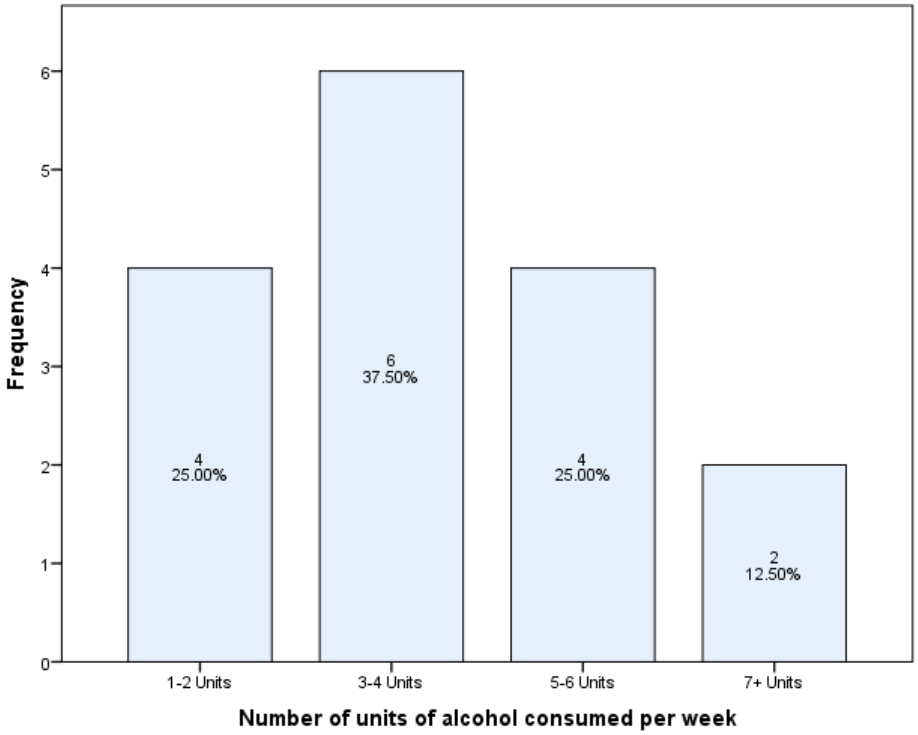


Figure 7. General drinking behaviour (*n* = 16)

Table 7 summarises the information then shown in Figures 8 and 9 regarding the dispersion of the data describing the relationship between alcohol consumption, age, BMI and weight. As shown in Table 7, there is a relatively low dispersion of age throughout all but the 3-4 units of alcohol group. The dispersion of weight follows the pattern seen previously with relatively high variation among those consuming 1-4 alcohol units per week and 7+ units with lower variation in the 5-6 units per week group. This trend also applied to BMI in relation to units of alcohol consumed per week.

Table 7

Age, body mass index, weight by weekly alcohol consumption (n = 16)

	1-2 Units			*3-4 Units*			*5-6 Units*			*7+ Units*		
	M	*Var*	*SD*	*M*	*Var*	*SD*	*M*	*Var*	*SD*	*M*	*Var*	*SD*
Age (Years)	28.82	2.81	1.68	24.72	13.93	3.73	23.34	2.20	1.48	27.28	4.79	2.19
Weight (kg)	80.00	232.00	15.23	64.50	168.70	12.99	66.00	18.00	4.24	79.00	242.00	15.56
BMI (Points)	23.45	11.82	3.44	23.04	6.41	2.53	19.80	0.20	0.45	25.19	35.28	5.94

When age distribution was examined in relation to drinking behaviour in more detail, approximately 50% of the sample fell either above, or below, the mean age. Figure 8 shows that a wider variation in drinking patterns was seen in persons above the mean age of 25.72 years.

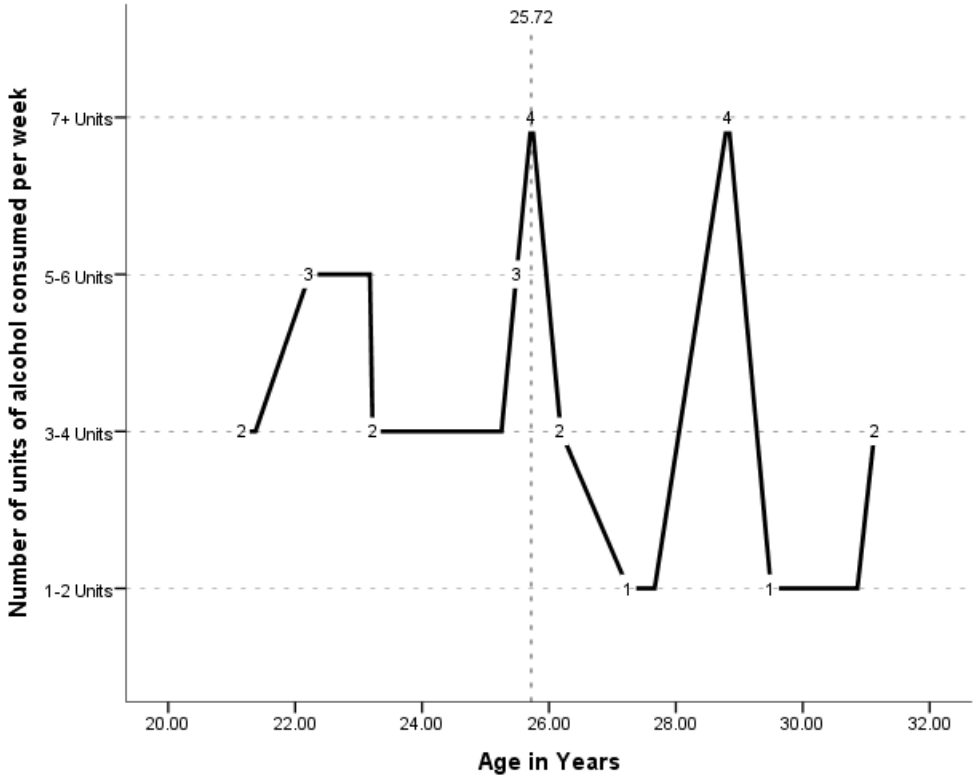


Figure 8. Age in relation to weekly alcohol consumption (*n* = 16)

When body mass index and weight are incorporated, shown in Figure 9, the sample data shows that persons drinking between 3 and 6 units of alcohol per week had lower weights and slightly lower BMI calculations. As Figure 10 shows, factoring in exercise stabilised BMI ratios regardless of alcohol consumption. The findings suggest that relationships between BMI, weight and exercise levels do not differ noticeably when units of alcohol are incorporated.

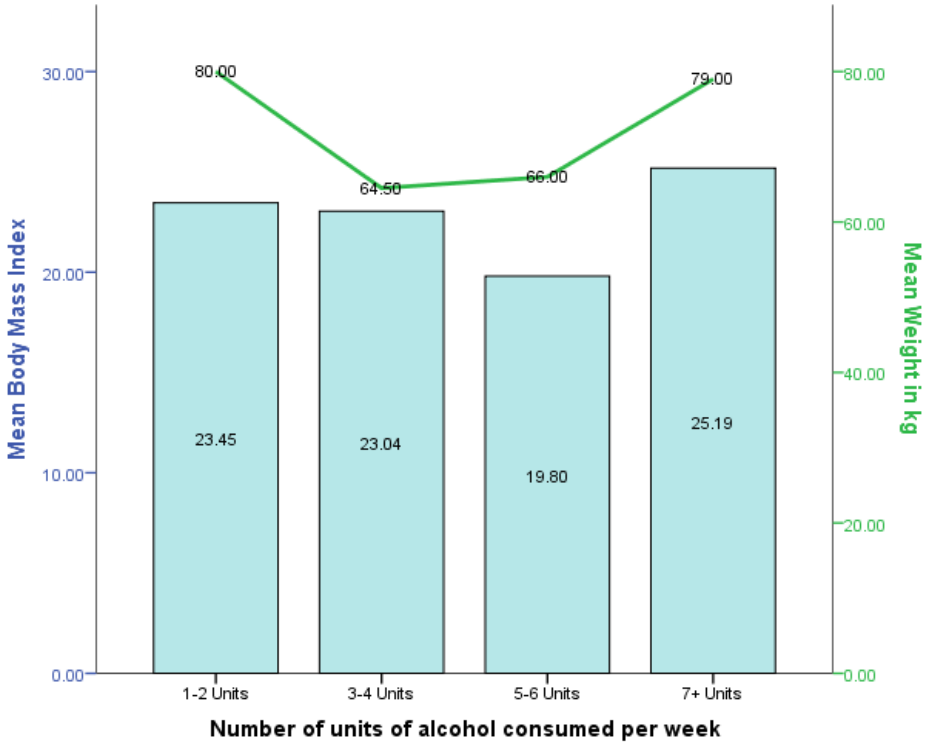


Figure 9. Mean BMI and mean weight per number of units alcohol consumed weekly (*n* = 16)

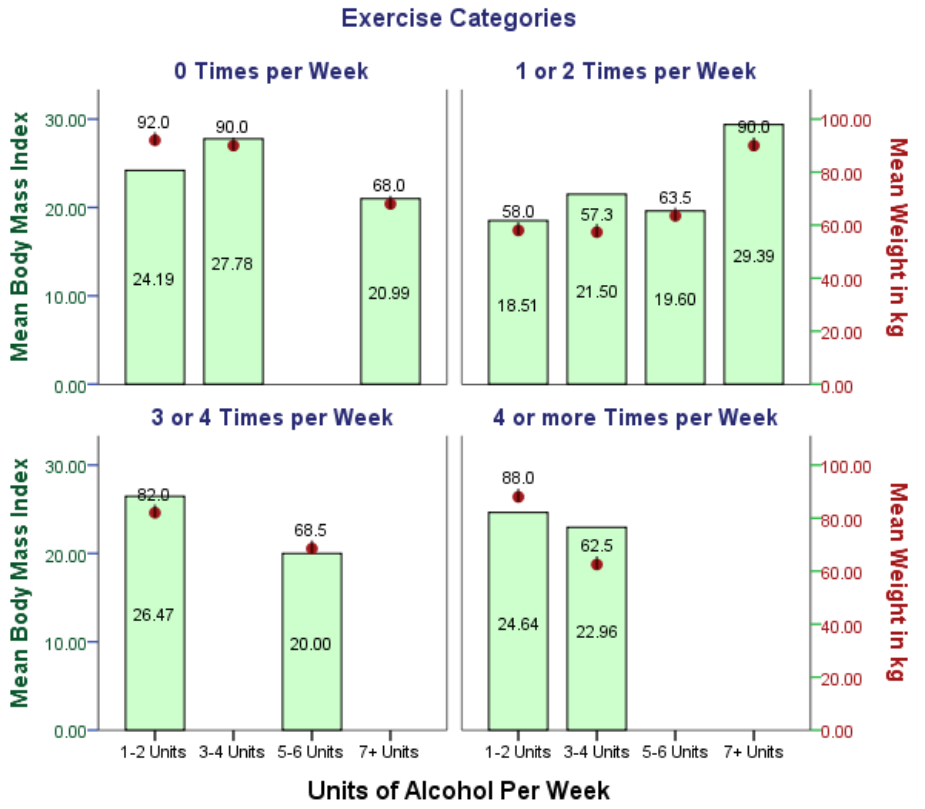


Figure 10. Mean BMI and Weight in relation to units of alcohol per week by exercise levels (*n* = 16)

Overall, the demographic data examined in relation to weekly alcohol consumption seem to indicate that mild-moderate consumption of between one and four units does not seem to be associated with increased weights or body mass indices. When exercise is accounted for, the stability of the relationship seems clearer for persons partaking in light exercise (1-2 sessions per week). Participants who did not exercise, and drank more during the week, had an expected tendency towards higher weights and higher BMI points scores. The preliminary analyses suggested that older participants tended to consume less alcohol and engage in less frequent binge drinking episodes. The relationships suggested that the separate use of participant age, BMI rather than its subcomponents, and the drinking indices was suitable for the inferential calculations. This relationship, and the general impact of alcohol consumption on the reported health/physiological characteristics considered, was expanded upon by incorporating binge drinking behaviours.

Binge Drinking Behaviour

Binge drinking episodes were classified categorically in increasing order of frequency. The initial definition of an "episode" encompassed the consumption of five or more alcoholic beverages in a single session. The number of sessions was classified according to episodes in the previous two months accounting for the two-week or more delay required for the inclusion of participants for health reasons. Due to relatively low frequencies per category and the lack of available specificity in reporting, grouped categories were deemed most appropriate. As reflected in Table 8, most of the participants reported engaging in 1 or 2 binge drinking episodes in the last two months (n = 8, 50.00%). The remainder did not report any episodes (n = 2, 12.50%) or reported 3 episodes (n = 6, 37.50%). No participants who were included in the study reported more than 3 binge drinking episodes in the previous two months as of the date of the first assessment.

Table 8

Frequency of Binge Drinking Episodes (n = 16)

	n	*%*
0 binge drinking episodes	2	12.50%
1-2 binge drinking episodes	8	50.00%
3 binge drinking episodes	6	37.50%

A description of trends applicable to both binge drinking episodes and normal weekly alcohol consumption (frequency of consumption) was also calculated. Table 9 and Figure 11

demonstrate the relative frequencies of binge drinking episodes and usual weekly alcohol consumption.

Table 9

Frequency of Binge Drinking Episodes and Weekly Alcohol Consumption (n = 16)

	1-2 Units		*3-4 Units*		*5-6 Units*		*7+ Units*	
	n	*%*	*n*	*%*	*n*	*%*	*n*	*%*
No binge drinking episodes	1	50.00%	1	50.00%	0	0.00%	0	0.00%
1-2 binge drinking episodes	2	25.00%	4	50.00%	2	25.00%	0	0.00%
3 binge drinking episodes	1	16.70%	1	16.70%	2	33.30%	2	33.30%

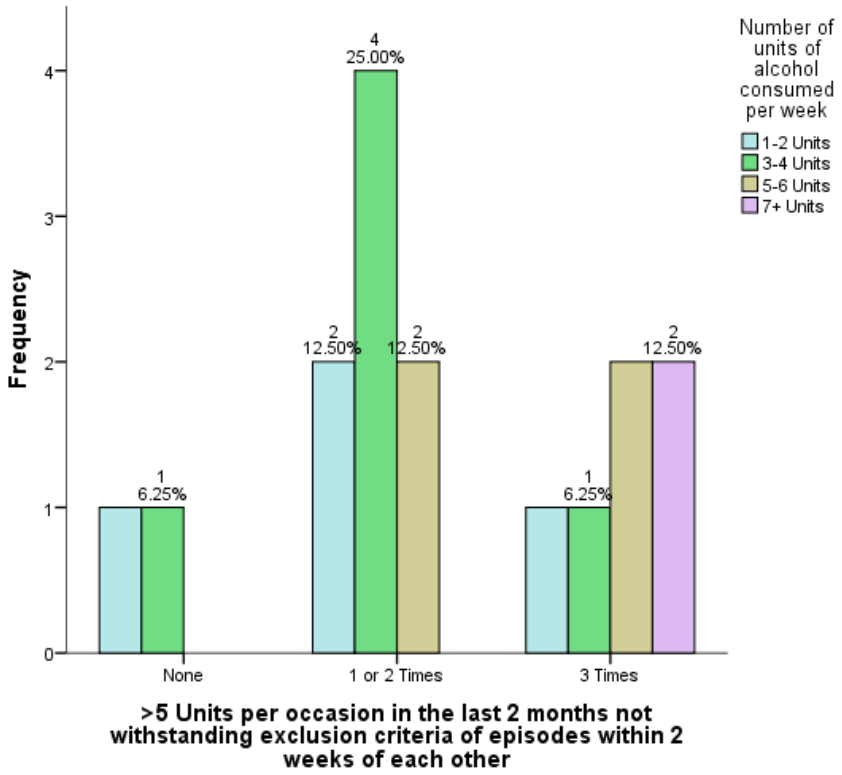


Figure 11. Frequency of binge drinking episodes in relation to weekly alcohol consumption (*n* = 16)

Table 9 and Figure 11 show that persons drinking 1-2 units of alcohol per week were split across the three categories but in low frequencies. More participants consuming 3-4 units of alcohol per week were in the 1-2 binge drinking episodes category. Persons who consumed 5-6 units of alcohol per week fell equally between the one, two or three episodes categories with none in the zero episodes category. Participants consuming the largest amount of alcohol during the week fell into the three episodes category. The data suggests that low levels of

alcohol consumption are not obviously related to binge drinking episodes, whilst higher general levels of consumption seem to increase the number of episodes. A brief comparison with the physiological characteristics was conducted for binge drinking episodes and to expand upon the previously referenced alcohol behaviours. Table 10 shows the dispersion and frequency counts of physiological information per binge drinking episode.

Table 10

Health/physiological Characteristics in Relation to Binge Drinking Episodes (n = 16)

	0 Episodes			*1 or 2 Episodes*			*3 Episodes*		
	M	*Var*	*SD*	*M*	*Var*	*SD*	*M*	*Var*	*SD*
Age (Years)	27.84	5.49	2.34	25.59	14.31	3.78	25.18	8.95	2.99
Weight (kg)	59	2	1.41	71.25	173.36	13.17	73.5	219.9	14.83
Body Mass Index	19.64	2.53	1.59	23.33	8.69	2.95	22.61	13.4	3.66

Table 10 shows low dispersion levels for age and BMI across all three binge drinking categories. Unlike weight, the dispersion in the second and third groups was considerably higher than in the zero episodes group. A low frequency of participants reported no binge drinking episodes, perhaps impacting the tabulation. The physiological characteristics can be examined separately and in relation to one another. Figure 12 shows the spread and trend of age in relation to binge drinking category.

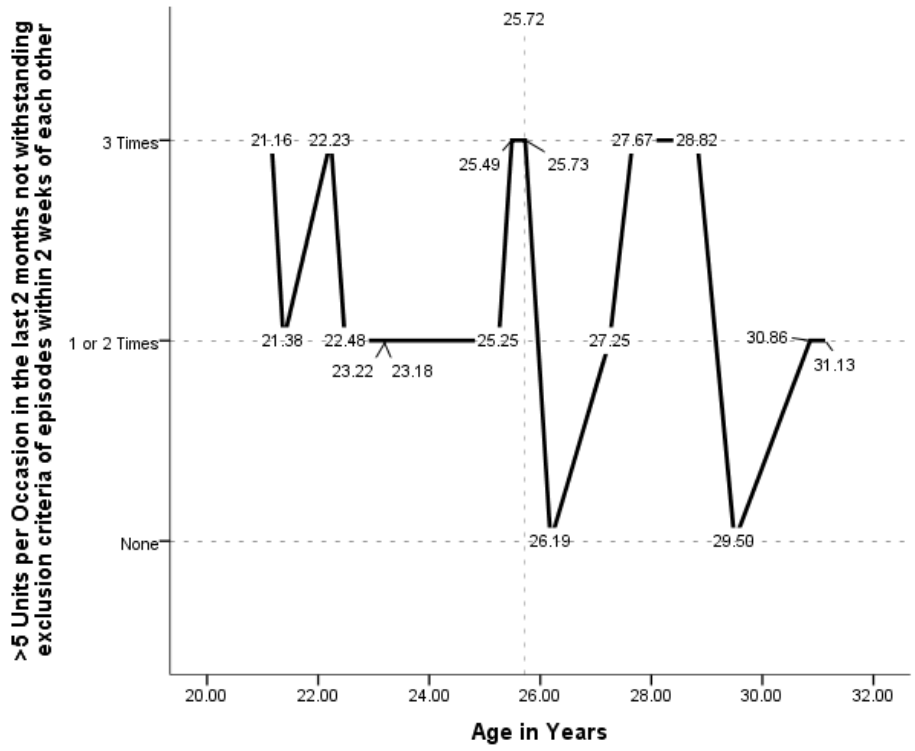


Figure 12. Age in relation to binge drinking (*n* = 16)

Based on the Figure 12, the number of participants who engaged in one or more binge drinking episodes within the last two months was evenly spread across the various ages displayed in the sample. The two participants who did not engage in any binge drinking episodes were above the mean age of the sample. Four of the six participants who engaged in three episodes of binge drinking were under the mean age of 25.72 years. No clear trend was demonstrated for the examination of age per binge drinking episodes, but this activity seemed less likely in older participants. Further to the examination of age, the BMI ratio was examined in terms of binge drinking levels and other health and alcohol related behaviours.

Figure 13 shows the ratio of weight-BMI to binge drinking categories. As discussed earlier, height is a constant factor in the calculation of BMI, whilst weight plays a more variable role if aspects such as muscle mass (exercise levels) are incorporated. Therefore, lifestyle factors such as alcohol consumption and exercise levels may influence this relationship.

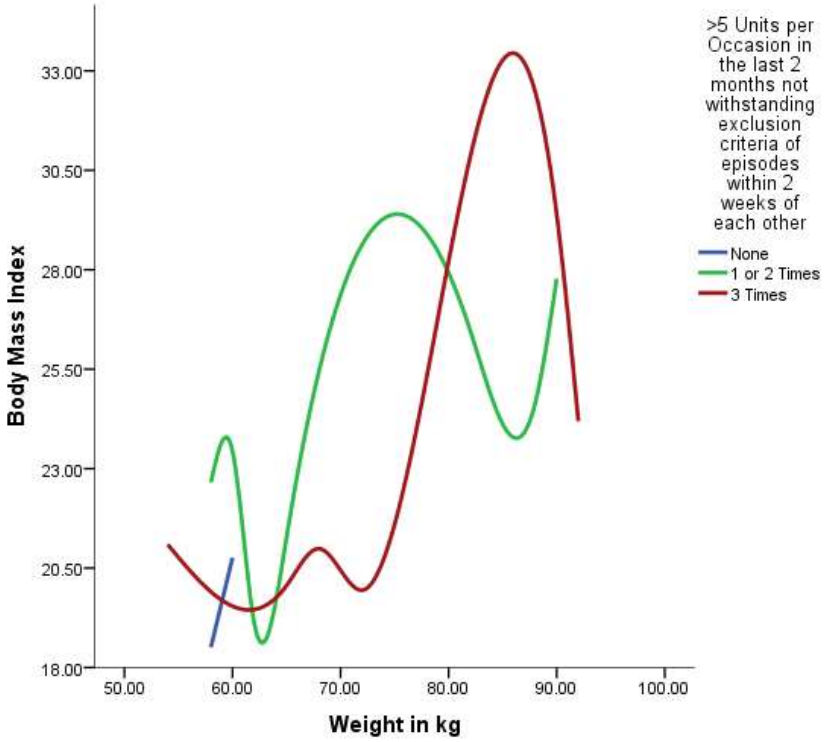


Figure 13. Weight to BMI relationships by binge drinking episodes (n = 16)

Participants who binge drink once or twice per week presented with a more modest curve displaying stronger central tendency in BMI values regardless of weight in kilograms than those in the three times per week category. This is consistent with the prior data presented regarding the weight to BMI relationship. As explained earlier, the weight-BMI relationship is stabilised by exercise levels making BMI points more stable as a general health indicator in this sample. However, this did not provide evidence for the exclusion of exercise levels in the

analyses involving BMI points. Lastly, average weekly alcohol consumption was also considered in relation to binge drinking and physiological variables.

As shown in Table 11, higher weekly alcohol consumption is somewhat associated with more frequent binge drinking episodes. Whilst approximately 25.00% (*n* = 4) of the sample consumed three or four units per week and engaged in one or two binge drinking episodes, the same percentage of the sample was associated with five or more units per week and three binge drinking episodes. Therefore, the proportion of participants consuming more alcohol per week reflected the proportion engaging in higher numbers of binge drinking episodes.

Table 11

Binge drinking episodes in relation to weekly alcohol consumption (n = 16)

	0 Episodes			*1-2 Episodes*			*3 Episodes*		
	n	*%*	*Sample %*	*n*	*%*	*Sample %*	*n*	*%*	*Sample %*
1-2 Units	1	50.0%	6.3%	2	25.0%	12.5%	1	16.7%	6.3%
3-4 Units	1	50.0%	6.3%	4	50.0%	25.0%	1	16.7%	6.3%
5-6 Units	0	0.0%	0.0%	2	25.0%	12.5%	2	33.3%	12.5%
7+ Units	0	0.0%	0.0%	0	0.0%	0.0%	2	33.3%	12.5%

Figure 14 illustrates the alcohol units per week versus binge drinking episodes graphically and it is notable that number of units consumed per week is proportionate to binge drinking episodes in the last two months.

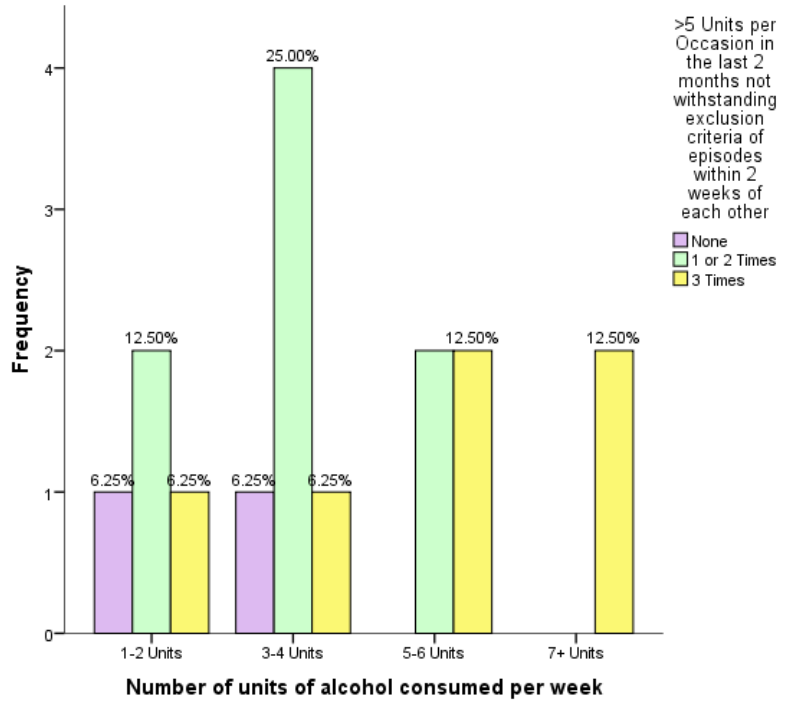


Figure 14. Binge drinking episodes in relation to weekly alcohol consumption (*n* = 16)

Physiological variables were noted in relation to weekly consumption and binge drinking episodes. Factoring in the age, weight and BMI levels of participants resulted in the information displayed in Table 12 and Figures 15 and 16.

Table 12

Mean Values: Age, Weight, BMI, Weekly Consumption per Binge Drinking Episodes (n = 16)

	0 Episodes		*1-2 Episodes*			*3 Episodes*			
Number of units per week	*1-2*	*3-4*	*1-2*	*3-4*	*5-6*	*1-2*	*3-4*	*5-6*	*7+*
Age (Years)	29.50	26.19	29.05	25.25	22.83	27.67	21.16	23.86	27.28
Weight (kg)	58.00	60.00	85.00	68.25	63.50	92.00	54.00	68.50	79.00
Body Mass Index	18.51	20.76	25.55	24.09	19.60	24.19	21.09	20.00	25.19

Note. Empty cells are omitted

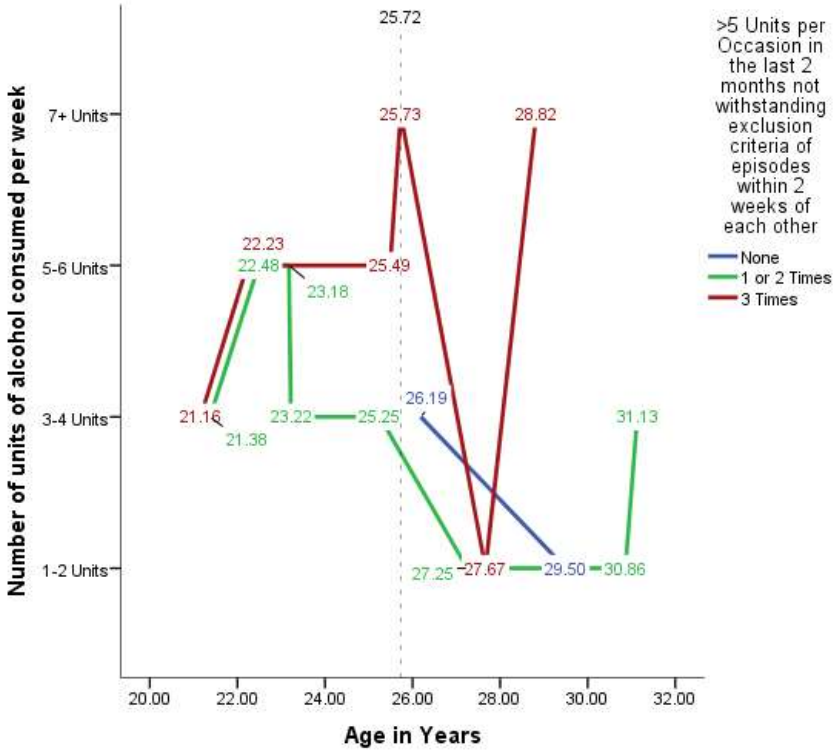


Figure 15. Age in relation to weekly alcohol consumption and binge drinking episodes (*n* = 16)

Participants close to, or below, the mean age seemed to consume more weekly units of alcohol and engage in binge drinking episodes. Older participants consumed less alcohol weekly and seemed to engage in fewer binge drinking episodes. Therefore, it appears that as age increases, engagement in alcohol-related behaviours seems to decrease proportionately. In

In Figure 16, weight to BMI ratios are displayed in relation to weekly consumption and binge drinking.

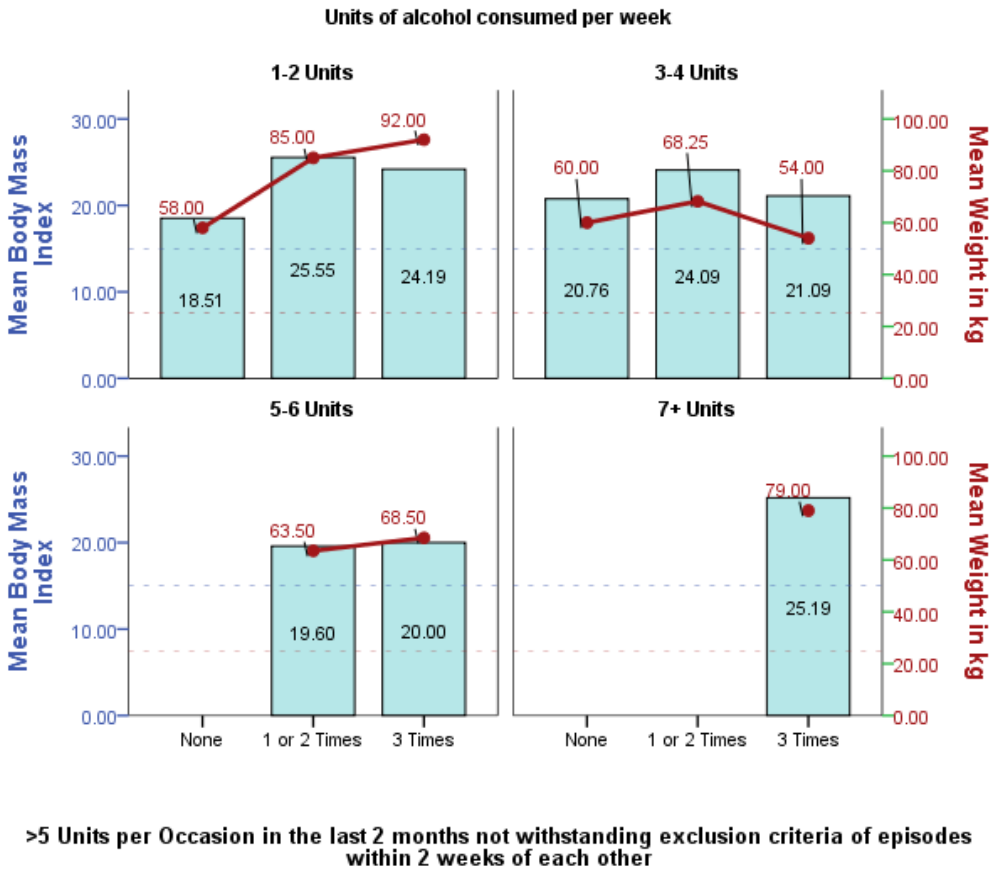


Figure 16. Weight-BMI ratios in relation to weekly alcohol consumption and binge drinking episodes (n = 16)

For the present sample, it appears that one or two episodes of binge drinking within a two-month period were consistently associated with normal BMI ranges. Exercise levels were previously shown to stabilise the BMI to weight relationship. Body mass index appeared to be a good indicator of overall health and higher average alcohol consumption did not seem to considerably impact this relationship. The sample characteristics described here are considered in terms of normality and homogeneity as they relate to the results of the inferential analyses in Chapter 6 (“Results”). These analyses determined the necessity, or lack thereof, of including any of the screening variables as covariates in the inferential models. For the inferential analyses, the preliminary covariates described were participant age, BMI, weekly drinking behaviours and incidences of binge drinking. Based on the sample characteristics, BMI was considered a sufficient indicator to incorporate height, weight and exercise levels as a single variable. The following sections discuss the nature of the instruments used in this research, the

procedures and the data analyses undertaken followed by an exposition on the important ethical issues which were considered during this study.

Instruments

The Automated Working Memory Assessment

The full theoretical foundation for the Alloway's (2007) Automated Working Memory Assessment (AWMA) was discussed in Chapter 3 detailing the theoretical foundations of the assessment of the different components of working memory theorised by Baddeley and Hitch (1974, 1983). Structural equation modelling during the instrument's validation study demonstrated four roughly analogous components, namely, short-term and working verbal memory as well as short-term and working visuo-spatial memory. The separation of the short-term and working components hypothetically accounts for the role of the central executive, applicable to working memory, but separately to basic storage (Alloway et al., 2006). In summation, verbal short-term memory is the ability to hold verbal information for a brief period, based primarily on phonetics (phonological loop) rather than semantics (linked to long-term memory functions). Verbal working memory refers to both the holding and manipulating of verbal information in memory. This construct on the AWMA is closely related to academic achievement and relies on working memory, rather than short-term memory. Visuo-spatial short-term memory assesses the ability to hold visuo-spatial information for a brief period without the necessity of manipulation of said information which is assessed by the spatial recall and spatial recall processing subtests making up the visuo-spatial working memory component of the assessment (Alloway, 2007).

Administration and scoring. The Automated Working Memory Assessment (AWMA) was utilised to obtain measures of short-term and working memory for both verbal and visuo-spatial modalities. The full assessment is comprised of 12 subtests, which form verbal short-term memory, visuo-spatial short-term memory, verbal working memory and visuo-spatial working memory composites as summarised in Table 13 and were discussed in detail in Chapter 3 (Alloway, 2007).

Table 13

Subsets and brief descriptions of the Automated Working Memory Assessment's components

Component	*Test*	*Description*
Verbal Short-term Memory	Digit Recall	Auditory presentation of a sequence of digits requiring recall in the correct order
	Word Recall	A sequence of words is heard and the individual attempts to recall each sequence in the correct order
	Nonword recall	The individual hears a sequence of nonsense words (nonwords) and attempts to recall each sequence in the correct order
Visuo-spatial Short-term Memory	Dot Matrix	The individual is shown the position of a red dot in a series of four by four matrices. Recall is demonstrated by tapping the square where the dot appeared
	Mazes Memory	The participant views a maze with a red path drawn through it then attempts to trace the same path on a blank maze
	Block Recall	A series of blocks being tapped are viewed and the sequence should be reproduced in the correct order by selecting on an image of the blocks
Verbal Working Memory	Listening Recall	A series of sentences are heard and judged to be true or false. At the end of the trial the individual attempts to recall the final word of each sentence in the presented order
	Counting Recall	The number of red circles in an array is counted then the tallies over several trials are recalled in the correct order
	Backwards Digit Recall	A sequence of digits is heard and should be recalled in a backwards order
Visuo-spatial Working Memory	Odd-One-Out	Three shapes are presented in a row and the individual must identify the Odd-One-Out. At the end of each trial the individual recalls the location of the odd shape out
	Mister X	A picture of two Mister X figures is viewed and the individual must identify whether the Mister X with the blue hat is holding the ball in the same hand as the Mister X with the yellow hat (blue hat Mister X may be rotated). At the end of each trial the individual attempts to recall the locations in the correct order based on markings of six possible positions
	Spatial Recall	The individual views two shapes where the shape on the right has a red dot and then identifies whether the shape (which may be rotated) is the same or opposite (mirror image) to the one on the left. At the end of each trial the individual should recall the location of each red dot in the correct order from three possible positions.

The AWMA is presented on a computer (see "Procedure" in this Chapter) and consists of the 12 subtests described above. Responses after each item, which increase in length and, therefore, difficulty, are recorded as correct or incorrect within the software via keyboard indication from the administrator. A continuation rule exists whereby the next level (length) of item is proceeded to following four out of the six possible correct responses. A discontinuation

rule terminates the subtest if four out of six responses are not achieved for a specific level (Alloway, 2007). The verbal assessments are administered in voice form only with a blank screen. Visuo-spatial assessments are administered in black and white presentation with strong colour indicators for specific objects or positions such as the hat in the Mister X subtest or Mazes Memory path. Composite scoring is conducted by the software resulting in a raw numerical score for each assessment, raw processing scores for each working memory assessment and standardised (normed) percentile scores relative to the age indicated. Scores may be exported in report and summary format for later use. The present research made use of the raw scores.

Internal consistency. In this research, Cronbach's alpha could not be calculated due to the inability to draw tabulations of "correct" and "incorrect" responses logged during the assessment. Cronbach's alpha (α_{Cr}) values of internal consistency have not been widely reported for the AWMA, leading to challenges in comparing the equivalence of the instrument over different groupings (Injoque-Ricle, Calero, Alloway, & Burin, 2011). Since the AWMA is scored as correct/incorrect with increased difficulty, based on the length of the items to be remembered rather than some other difficulty quotient, a medium-high to high value could be realistically assumed in a carefully developed instrument at least for each specific subtest. For comparative purposes, particularly of the visuo-spatial items, a useful Spanish adaptation study using 26 children of approximately 13 years old by Injoque-Ricle et al. (2011) reported Cronbach's alpha values of $\alpha_{Cr} = .75$, $\alpha_{Cr} = .61$ and $\alpha_{Cr} = .75$ for Word recall, Nonword recall and Listening recall respectively. Similar findings were reported by Absatova (2015) for a Russian translation. Cronbach's alpha is a strong indication of equivalence of parallel forms and, by extension, homogenous items (Cronbach, 1951). The values reported for the small sample seem somewhat low despite Cronbach's (1951) assertion that the percentage variance considered by the alpha value is primarily accounted for by a principle common factor alongside a small amount due to other common factors. In this case, the values obtained may be due to attenuation based on intrinsic reliability or, as is more likely with a small sample size, standard errors of measurement within the instrument, which influence the respective standard deviations or calculations of variability. Since the values for the considerably larger sample used by Absatova (2015) are more acceptable, as presented in Table 14, it is most likely that the small sample size used in the brief pilot attenuated the results of the calculations.

Table 14

Cronbach's Alpha Values for Internal Consistency of the AWMA (Absatova, 2015)

AWMA Subtest	*Cronbach's α*
Digit Recall	.88
Word Recall	.87
Nonword Recall	.81
Dot Matrix	.91
Block Recall	.92
Mazes Memory	.95
Listening Recall	.91
Counting Recall	.90
Backwards Digit	.89
Odd-One-Out	.91
Mister X	.89
Spatial Span	.92

A danger in interpreting Cronbach's alpha for assessments such as the AWMA is the small number of items and method of moving between item difficulties since more difficult items are not attempted. As Cronbach (1951) suggested, lack of reliability in individual responses accounts for rapidly decreasing proportions of the variance, providing that items represent the same factors, or constructs. Consequently, the attenuating contribution of unreliable items is inversely proportional to the length of the test. The AWMA, as a performance limited test, may be prone this weakness, particularly in poor performers who only succeed in progressing through a small number of the items. Injoque-Ricle et al. (2011) acknowledged this weakness and elected to administer the full assessment without discontinuation rules thereby producing what is likely to be a more accurate reflection of the consistency of the items within each subtest as well as reducing the influence of poorly functioning items. However, the results obtained my not be generalisable to the "correct" administration of the battery in which poor items may have increased influence when the discontinuation rules are implemented. Nonetheless, the values reported in Table 14 (Absatova, 2015) are promising in terms of adhering to the commonly quoted standard of $\alpha_{Cr} = .70$ or higher (Anastasi & Urbina, 1997; Lance, Butts, & Michels, 2006). However, Lance et al. (2006) do cite evidence to refute the origin of the common claim of the $\alpha_{Cr} = .70$ standard quoted by many, referring to Nunnally's often cited work in 1978 which suggested that values of $\alpha_{Cr} = .90$ as a minimum, $\alpha_{Cr} = .95$ are desirable. Although the items on the AWMA did not fully satisfy this criterion, the values reported are sufficient to meet commonly accepted standards. However, further investigation would be required to examine the internal

consistency of all components and subtests to ensure the equivalence of hypothetical splits and stability reflected in Cronbach's alpha which is influenced by erratically functioning items. Erratic functioning items also influence the temporal stability of the instrument which is considered a component of reliability.

Temporal stability. Alloway et al. (2006) explored the temporal reliability of the AWMA with a sample of approximately 700 school children of which a stratified random sub-sample, accounting for school achievement levels, was used to investigate temporal stability over a three-week delay. Age and gender were also considered, neither of which seemed to influence the reliability of the assessment. The researchers reported variable Pearson's *r* values between the two occasions, with the majority fluctuating around $r = .80$. These values are comparable to studies using adults with other assessments of working memory and intelligence (cf. Lo, Humphreys, Byrne, & Pachana, 2012). Calculations of temporal reliability are dependent on variance and covariance within the sample. Covariance is dependent upon the sum of the multiplicands of the dispersions of each point from the mean calculated using the sum of squares of these same values with a divisor of n-1 degrees of freedom, differences from the mean over the x (initial test) and y (retest) time points strongly influence the outcome of the calculation. As a result, the introduction of unwanted variance from practice effects, semantic memory, improved understanding of example content or other factors may influence these calculations. Ideally, the test-retest reliability, or stability, of an instrument should be completely free of any factors influencing the outcome over the two occasions (Rosenthal & Rosnow, 2008). In practice, however, this is usually not possible.

In the present research, test-retest delays varied considerably (*Min* = 28 days, *Max* = 213 days, $M = 87.38$ days, $SD = 52.59$ days). It is to be expected that such variation will influence potential practice effects to some degree although this should be attenuated by the minimum delay of 28 days required by the research design. Influence from factors such as schooling, which make temporal stability studies with children challenging, is unlikely in a sample of adults. Due to the introduction of the experimental condition, it was not considered appropriate to consider the test-retest reliability for this sample as the nature of the influence of alcohol was not known. However, the delays were considered in the inferential analyses. Table 15 shows the temporal stability values found by Alloway et al. (2006).

Table 15

Test-retest reliability values for the AWMA (Alloway et al., 2006)

	Subtest	*r*
Verbal Short-term Memory	Digit Recall	.84
	Word Recall	.76
	Nonword Recall	.64
Verbal Working Memory	Listening Recall	.81
	Counting Recall	.79
	Backwards Digit	.64
Visuo-Spatial Short-term Memory	Dot Matrix	.83
	Mazes Memory	.81
	Block Recall	.83
Visuo-Spatial Working Memory	Odd-One-Out	.81
	Mister X	.77
	Spatial Recall	.82

The values presented by Alloway et al. (2006) are sufficient for a psychometric instrument to be said to possess temporal stability, with the requirement as $r = .70$ or higher. However, as discussed regarding coefficient alpha, this standard may not be sufficient for psychometric assessments, despite being commonly cited (Anastasi & Urbina, 1997; Lance et al., 2006). A notable exception to the average values is the $r = .64$ statistics obtained for the Nonword Recall assessment of short-term memory and Backwards Digit assessment of working memory. Alloway (2007) describes the Nonword Recall assessment as free of semantic memory influence and the Backwards Digit assessment as resulting in high processing load demands, neither of which should be subject to subliminal practice effects. The researchers did not hypothesise a cause for the lower coefficients presented for the two subtests mentioned but unique influences at the time of testing may have been influential. Similarly low values were also reported in a different study, in which the researchers hypothesised that experience with using numbers may influence the stability of the Backwards Digit assessment (Alloway et al., 2008).

By comparison, Lo et al. (2012) used the Wechsler Memory Scale which includes several memory subtests similar in nature to those in the AWMA's working memory components. Over two to seven years, the researchers examined the test-retest reliability of the subtests in women of forty years and older, stratified by age group and controlling for intra-personal factors such as health. Tests of immediate Logical Memory, Forward and Backward Spatial Spans, Delayed Memory, Paired Associates and Sequencing produced Pearson's *r* values of between .44 and .75, remaining stable per assessment, or subtest, when compared

over three occasions. In contrast to increased reliability as children aged, the reported reliability coefficients were lower for older persons (cf. Alloway et al., 2006 who studied children). Although the temporal stability over younger age groups seems adequate, the stability of working memory assessments may decline with increased age, not accounting for significant differences in performance attributed to practice effects (Lo et al., 2012).

Latent structure of the AWMA. Alloway et al. (2006) describe the structure of the AWMA. Correlational analyses across the various age brackets between 4-11 years, demonstrated relationships of between $r = .56$ and $r = .73$ for the verbal short-term memory tasks, $r = .69$ and $r = .74$ for the verbal working memory tasks, $r = .68$ to $r = .75$ for visuo-spatial short-term memory, and $r = .64$ to $r = .73$ for visuo-spatial working memory. These dropped considerably to between $r = .35$ to $r = .62$ when age was partialled out. All correlation coefficients between the subtests and factor totals were significant at the 99% level in Alloway et al.'s (2006) study. Alloway et al. (2006) further examined several potential models for the AWMA data using factor loadings and goodness of fit statistics including Chi-square, root mean square error of approximation scores and other incremental measures. The model considered the best fitting, which best reduced collinearity between the components, consisted of three components analogous to verbal short-term memory, visuo-spatial short-term memory and working memory. These components are reminiscent of the phonological loop, visuo-spatial sketchpad and central executive which formed the foundation of the instrument.

Models based on findings for older children were appropriately loaded to the relevant short-term memory component and executive (working) memory component with acceptable values of goodness of fit statistics significant although some Chi-square values were statistically significantly different ($p < .01$) from the predicted covariance matrix. Therefore, the findings may not be applicable to the general population. The model produced for 9-11 year olds, presenting the best fitting data, with coefficients between $r = .43$ and $r = .71$ between the three identified components. This confirms the utility of the AWMA latent structure in assessing working memory, although this was not the primary focus of the discussion following their investigation. It can be cautioned that larger sample sizes, as used by Alloway et al. (2006), can produce significance where none is warranted (Rosenthal & Rosnow, 2008). However, Ho (2006) suggests a minimum sample size ratio of 10 respondents per parameter, thereby increasing the sampling requirements for model fit along with the complexity of the model. Based on this information, and accounting for the sample size used in the model derivation study, Alloway et al.'s (2006) study is likely to be a good reflection of the latent structure of the instrument and is in line with the Baddeley and Hitch (1974, 1983) theoretical

models. In this case, *r* values obtained between the three theoretical components are sufficient to suggest association, but not so high as to suggest a single construct. Other studies suggest that components of the model may also be applicable to non-British samples (Absatova, 2015; Nadler & Archibald, 2004). For the present study, no factor analytic analyses were used due to the small sample size and introduction of extraneous variance under the experimental condition. However, the correlational structure of the AWMA is considered in Chapter 6, "Results". In this case, excessively high test-retest correlations were undesirable as these would suggest an absence of influence of alcohol. However, the internal correlations appeared sufficient to confirm the hypothesised structure of the AWMA as an instrument although some exceptions were present.

Validity. The AWMA demonstrated convergent validity when correlated with scores on the Wechsler Intelligence Scales for Children IV (WISC-IV) Working Memory Index (WMI). This research, conducted by Alloway et al. (2008), focused on the diagnostic utility of the instrument in children with poor school achievement and potential working memory deficits. Assessments of children with low working memory, based on the results of the Listening Recall and Backwards Digit Recall AWMA subtests, were compared with performance on the WISC-IV memory subtests. The results revealed lower WISC-IV memory subtest scores for the children classified as low working memory by the AWMA in 80% of cases when the full instrument was used and up to 91% of cases for the Digit Span score. Listening Recall and Backwards Digit, proved useful in classifying children according to level of working memory function which established some convergent validity with the WMI. Similar findings by Holmes, Gathercole, Place, Alloway and Elliot's (2010), focusing on children with Attention Deficit Hyperactivity Disorder (ADHD), were also promising in evaluating the validity of the AWMA.

In Holmes et al.'s (2010) research, the Delis-Kaplan Executive Function System and AWMA tests of verbal and visuo-spatial short-term and working memory were used and the researchers found that all the executive function assessments, in combination with short-term memory assessments, were useful in this classification process. A useful finding from this research was the equivalent performance of the two different working memory assessments, as well as the usefulness of short-term memory assessments on the AWMA in the diagnostic procedure. These findings suggest a global memory executive construct rather than separated components. Examination of the latent structure presented in Holmes et al.'s (2010) study suggested that short-term memory processes are free of conscious processing but only for certain subtests, primarily the Nonword Recall and Dot Matrix assessments, which may be free

of executive processing. However, Ericsson and Kintsch (1995), for example, emphasised the potential role of long-term memory and semantic processes in working memory. The complexity of the short-term and working memory systems may not be fully separable in the case of Holmes et al.'s (2010) research since children with ADHD were sampled. This may be due to multi-faceted consequences of the disorder. Nonetheless, the predictive validity provides evidence for the function of the AWMA although the complexity of the processes should be noted.

Fairness. In the present research, the fairness of the instrument per culture or socio-economic status was not deemed essential to its functioning as test-retest comparisons were examined. This is a strength of the repeated measures design, allowing each participant to operate as his or her own control, thus negating potential differences between ethnic or language groups. The instrument was used for obtaining and comparing of scores only, not classification of individuals on a normed continuum for categorical, comparative or diagnostic purposes. Nonetheless, familiarity with testing and the nature of measurement by assessments may differ across cultures (Anastasi & Urbina, 1997). In this regard, the AWMA has been found to be appropriate in terms of socio-economic status and culture fairness. These studies are briefly discussed for informational purposes and to illustrate the absence of dramatic differences based on cultural groupings in the present sample.

Engel, Santos and Gathercole (2008) examined the fairness of the AWMA in relation to socio-economic status in matched samples of children in Brazil. The findings indicated that only performance on the Counting Recall subtest scores differed significantly across the three different socio-economic groupings where a medium effect size (Cohen's *d*) was reported. Researchers in Canada, Russia and Argentina have also investigated the fairness of the AWMA subtests. Nadler and Archibald (2014) recorded correlations between the subtests close to those found by Alloway et al. (2006). Injoque-Ride et al. (2011) reported between-test correlation coefficients like those reported by Alloway et al. (2006), as well as some relationship to other assessments of working memory. However, the Canadian children did show above average performance on the Counting Recall subtest. Similar findings, reflecting the equality of the instrument across cultures, were produced for a Russian sample of children for nonverbal constructs (Absatova, 2015). The AWMA was the primary focus of this research and the outcome variable for the measurement of the impact of alcohol on working memory. As mentioned in Chapter 3, working memory functions may be mediated by intelligence levels. To account for this potential covariate, baseline scores on the Raven's Progressive Matrices (Standard Form) were measured as a language-free reflection of intelligence levels.

Raven's Progressive Matrices (Standard Form)

Whether working memory and fluid intelligence are isomorphic, separable or part of a co-dependent system of functions, support for a psychometric relationship between them exists (Ackerman et al., 2005; Conway et al., 2002). The Raven's Progressive Matrices (Standard Form) was used to assess fluid intelligence free of the potential influences of language to potentially measure its influence on working memory (Raven et al., 2000). The standard form was selected based on reference to the manuals indicating it as appropriate for the general population targeted in this research.

Administration and scoring. The RPM is administered via black and white booklet and standard paper/pencil answer sheet as per manual instructions (Raven et al., 2000). One item appears per page of the booklet where the stimulus encompasses approximately one-third of the page. Therefore, the item stimulus and answer options are large and clear. Administrators are required to explain the purpose of assessment and how to respond to the stimuli given by marking the appropriate option on the answer sheet. The RPM requires the respondent to examine patterned or sequenced visual stimuli and select from the available options the most appropriate to complete or conclude the pattern or sequence as well as to complete the first two (A-1 and A-2) with the participant and with explanation of how the correct response was obtained. The five sets (A to E) of twelve items increase in difficulty and number of options with a minimum of 6 response options and a maximum of 8 response options in the later sets. The first set requires the completion of a clear pattern, for example, black and white zig zags. Later sets require the identification of a sequence within a pattern and insertion of the most logical option into the missing section. Scoring is marked as correct (1) or incorrect (0) by the administrator based on a stencil or answer form indicating correct responses. Scores for each set are totalled out of 12 possible correct marks per set and 60 possible total marks over the 5 sets or total instrument. The final score out of 60 is used interpretively to compare to wide-scale United States of America based norms relative to age. Thereby, a percentile score relative to that population is noted. The present research made use of the raw scores only to avoid any confounding due to cultural, or language, factors. Internal consistency, temporal stability and validity studies have been conducted using the RPM. The data obtained for this research sample is also considered for comparative purposes.

Internal consistency. Cronbach's alpha values of α_{Cr} = .846 and α_{Cr} = .929 were reported on the RPM for South African samples from various ethnic and language heritages (Owen, 1992). These values were similar to those reported by Raven et al. (2000) for their

American sample. Since alpha is constructed according to covariance and relative proportions of well and poorly functioning items, values in this range indicate the measurement of some common construct across all items. High values suggest little variance across persons. Owen (1992) calculated item difficulties and discrimination values for a sample of South Africans between 20 and 30 years of age. All the groups found half of the items difficult, evidenced by item difficulty values of $P \leq 0.30$ (approximately 30% of respondents answered correctly), where items C-12, E-11 and E-12 were the most challenging. Nonetheless, after examination of the correlations between item difficulty orderings between the various groups, Owen (1992) concluded that the instrument seemed to be measuring the same construct per item across all groups. In the present study, the Cronbach's alpha value and other statistics were applied to the sample obtained for comparison to published research. However, the nature of the sample in this research was significantly different from that of Owen (1992), or studies reported by Raven et al. (2000), which focused on large scale validation across a variety of persons and age groups. Therefore, it is unknown if the instrument can function in a directly comparable manner.

For the current sample, statistics were calculated using methods appropriate for binomial/dichotomous response (yes/no) items. Nineteen items were removed from some calculations due to zero variance as all participants answered correctly. These items were A-1 through A-3, A-5, B-1 through B-4, B-10, C-1, C-2, C-5, D-1 through D-6 and E-3. The items were removed to remediate the potential inflation of internal consistency values due to lack of variance and permit correct computation of matrices. Therefore, 41 items with some variance remained for the examination of internal consistency. The unstandardized and standardised α_{Cr} values, split half reliability for the full scale and each of the 5 (A-E) sub-scales along with various permutations is presented in Table 16, following this discussion. The use of different statistics, each with their own assumptions, makes drawing conclusions based on a single statistic challenging (Cronbach, 1947; Kuder & Richardson, 1937). The summing of raw scores is best suited to the covariance matrix (unstandardised alpha) whilst the summing of standardised scores, transformed during the calculations, is best suited to the standardised form of alpha, particularly where the items demonstrate substantial differences in variance (Falk & Savalei, 2011; Warrens, 2015). In this research, split-half reliability calculations were also considered, primarily for comparative purposes. These included the Spearman-Brown predictive split halves and Guttman method. These methods focus on maximising covariance in calculations of the coefficients, in the case of Spearman-Brown, and reducing the assumption requirements of the data (Guttman) using algorithmic summation methods (Eisinga, te Grotenhuis, & Pelzer, 2013).

Table 16

Cronbach's Alpha Values for the Raven's Progressive Matrices (Standard Form) (n = 16)

	Cronbach's Alpha			Split-Half Reliability					
	n items	Unstandardised α_{Cr}	Standardised Items α_{Cr}	Split-Half Part 1	Split-Half Part 2	*r* between forms	Spearman-Brown: Equal Length	Spearman-Brown: Unequal Length	Guttman Coefficient
Full Scale	41	.848	.809	.437	.853	.536	.698	.701	.517
Set A	8	.201	.101	-.143	.438	-.303	-.869	-.513	-.435
Set B	7	.283	.291	1.00*	.407	-.194	-.480	-.352	-.381
Set C	9	.607	.531	.310	.754	-.163	-.389	-.294	-.219
**Set D	6	.221	.169						
Set E	11	.782	.779	.631	.728	.511	.676	.678	.668

* Only two items (B-1, B-2) which all participants answered correctly were included in this half

** Split-half reliabilities were not calculated as too many items had been removed from the scale due to zero covariance

The differences in the statistics shown in Table 16 may be due to Cronbach's coefficient alpha being subject to increased bias in the case of the assumption of scores being congeneric is met (Eisinga et al., 2013). Tau-equivalence based on equal halves could not be assumed in the present research, making unstandardised alpha coefficients somewhat unreliable (Feldt, 1975). The Spearman-Brown statistic intends to predict reliability for various instrument lengths requiring the strict assumption of parallel forms (Warrens, 2015). On the other hand, Guttman's coefficient is based on reproducibility, focusing on the ability of a single item to predict responses on easier items (Guttman, 1945). Since only the number of persons and number of items can contribute to variance in the assessment of internal consistency, considering the present research sample size makes interpretation of the statistics challenging and an overestimation of the statistics likely (Benton, 2013).

Shown in Table 16, above, the full RPM, which consisted of 41 out of 60 items which showed variance, produced substantial standardised and unstandardized coefficient alpha values. The split-half values, however, were somewhat variable. Benton (2013) warns of Guttman's coefficient overestimating reliabilities for small sample sizes. However, for these calculations, the resultant statistic was substantially lower than that of alpha or Spearman-Brown. In fact, throughout the various combinations, the Guttman coefficients produced were extremely variable in comparison to the alpha and Spearman-Brown values. This may have been due to the sample size along with the reduction in items due to the absence of variance leading to the removal of certain items. These values seem sufficient to use the results of the RPM for this sample with some degree of confidence in its measurement of the intended factor. When the sets were examined separately, it appeared that Set C and Set E had the highest statistics of internal consistency, aside from the full scale. The full scale was utilised for later analyses and the coefficients were deemed sufficient.

Temporal stability. In the present research, the RPM was administered only once. However, temporal stability is important to ensure the reliability of the measure utilised. There is evidence of considerable increases in performance on the RPM over an extensive period, known as the Flynn effect, requiring redistribution of the norms used as a benchmark for the assessment (Raven, 2000). However, Raven (2000) also reported consistency in the manner of measurement of the instrument over this period, suggesting a stable and reliable test. More recently, Raven et al. (2003) presented research studies reporting poor (around $r = .50$) test-retest correlation coefficients in samples of children. This was considered unsurprising, given the rapid development of cognitive and intellectual and reasoning skills during the formative years. Raven et al. (2000) continue to discuss the temporal stability of the instrument referring

to various international studies producing short-term (matter of weeks or months) test-retest coefficients in the region of r = .75 and higher. The stability of the RPM over a variety of time periods has been demonstrated (Raven et al., 2000). Since test-retest consistency (stability) was not of high importance to the current, compared to internal consistency or equivalence, the values reported should be sufficiently high to demonstrate no general instability when the measure is used for adults.

Latent structure and validity. Raven et al. (2003) define *g* (a general intelligence factor) as founded in eductive and deductive reasoning. These constructs and relationships were discussed in Chapter 3. Therefore, the RPM items should ideally measure only this single construct. Owen (1993) used a young adult (<25 years) South African sample and conducted factor analyses based on tetrachoric correlations, suitable for two dichotomous variables, concluding that the RPM measures a single construct. Owen's (1993) South African data was based on principal components factor analysis without rotation to maximise the variance explained by the first, or overarching, factor. Factor loadings ranged from close to zero values to values of more than .90 in some cases. This held true across cultural groups which were the primary focus of the study.

The values reported by Owen (1993) do not necessarily provide sufficient evidence for a single construct. Raven et al. (2003) describe similar high loadings across norming studies ranging from .81 to .93 for most items although some studies have reported values of explained variance as low as 48.63% (Bors & Stokes, 1998) and reported the presence of more than one factor (cf. Raven et al., 2003). Other factor-structure findings have reported a two-component model (Sets B and E) (van der Ven & Ellis, 2000) and a three-factor model in adolescents (Lynn, Allik, & Irwing, 2004). For the purposes of this research, it is noted that Set C and Set E show stronger internal consistency. However, the assessment of a single factor structure was not possible due to the absence of variance in several items.

The studies by Owen (1993), as well as those reported by Raven et al. (2003), appear sufficient to suggest a single factor. This single factor has been shown to be associated to some aptitude and intelligence assessments including the School and College Ability Test for gifted students from minority populations (Mills & Tissot, 1995), the Wechsler Intelligence Scale for Children – Revised and the Meekers Structure of Intellect Screening Form (Pearce, 2016). These studies, alongside those reported in the manuals, seem to confirm the latent structure and validity of the RPM as an instrument. Studies of fairness provide further support for the integrity of the instrument.

Fairness. Large international studies on comparisons on the RPM did not reveal considerable influence by gender or socio-economic status, although age did play a role in children and young adults (Raven, 2000; Abdel-Khalek & Raven, 2006; Rushton, Skuy, & Bons, 2004). Rushton and Skuy (2000) noted small gender differences, favouring males, but concluded the difference was unrelated to *g*. Internationally, similar normative data has been collected for the RPM and other instruments for a variety of countries and cultures whilst remaining largely free of gender bias (Abdel-Khalek & Raven, 2006). Culturally based, rather than gender focused, studies of the RPM have been conducted internationally and in South Africa.

Although extensive analyses of the RPM demonstrated little or no cultural bias (Raven, 2000). However, Owen (1992) concluded that, for the sample utilised, RPM items remained consistent in their measurement of general fluid intelligence (*g*) whilst discriminating between ethnic groups The RPM also discriminated within ethnic groups, thereby measuring individual differences in *g*, rather than ethnic group differences due to cultural bias (Rushton & Skuy, 2000). Rushton, Skuy and Fridjhon (2002) confirmed that higher item-total correlations seemed to enhance differences between cultural groups and that Black African groups tended to score in a lower percentile than White students, calling into question the use of norms in South Africa. However, this study may have been influenced by educational background. As mentioned, the present research made use of the raw scores rather than norms, thereby by-passing this limitation.

The Brief Biphasic Alcohol Effects Scale (B-BAES)

Few studies of the impact of alcohol on working memory have included measurement of subjective intoxication, preferring to rely on placebo effects (e.g. Saults et al., 2007). The current research included a measure of subjective intoxication for the purposes of understanding expectancy to assess potential differences in the stimulated and sedated domains following alcohol consumption. The Biphasic Alcohol Effects Scale was developed to assess the subjective stimulant and sedative properties of alcohol consumption (Martin et al., 1993). Following the elimination of items which were difficult to comprehend, based on ratings by sober students, the researchers administered the assessment to students receiving 0.75 ml/kg body weight alcohol (males) or 0.65 ml/kg body weight (females). Cronbach's alpha values of $\alpha_{Cr} = .85$ to $\alpha_{Cr} = .94$ were obtained for the final 14 item scale along with test-retest values over two weeks of between $r = .23$ and $r = .70$ for the original 24 item scale which was later reduced to only 14 items. Further consideration of the two-component structure (confirmatory factor

analysis) sub-scale produced Cronbach's alpha values of α_{Cr} = .87 to α_{Cr} = .94 for the sedative and stimulant scales respectively. Item-total correlations ranged between *r* = .58 and *r* = .86 with a mean value of *r* = .65 for the sedative sub-scale and *r* = .81 for the stimulant sub-scale. Since it can be assumed that both sedative and stimulant reports are positively correlated with intoxication at different points, the structure mentioned was obtained based on factor analysis employing oblique rotation to maximise variance.

Two hypothesised factors were identified and were confirmed in a Polish adaptation of the scale (Poprawa, 2015). Martin et al.'s (1993) scale consisted of 14 items potentially creating challenges when used in a practical setting given the rapid metabolism of alcohol, particularly if small quantities are administered (Rueger & King, 2013). This concern was echoed in the design of the current research whereby multiple subjective intoxication and BAC readings were required. A shorter version of the BAES, the six item Brief Biphasic Alcohol Effects Scale (B-BAES), was validated using a sample of 104 drinkers during a laboratory study (Rueger & King, 2013). Six items, rather than fourteen, were used which were rated on a consensus scale of one to ten. The items, "Energized", "Excited", "Sedated", "Slow Thoughts", "Sluggish" and "Up", produced the same two-factor structure as found in the original BAES validations (Rueger & King, 2013).

In the current research, the B-BAES values were recurring over fourteen points ranging from pre-alcohol consumption to post alcohol consumption and before each of the twelve AWMA subtests (see "Procedure" in this Chapter for more). This allowed measurement across all points of the apparent BAC curve obtained in the research. The instruments structure is examined in relation to average BAC later in this chapter for functional use during the study in answering the specified research questions in the results (Chapter 6). Therefore, a specific scale was developed for further usage for the present research's requirements.

Research Design and Procedure

Research Design

Demographic information on age, ethnicity, height, weight, body mass index, average exercise levels, usual alcohol consumption and heavy drinking episodes was collected prior to invitation or agreement to participate. The information was collected via an online survey which also served as a screening tool to ensure potential participants met the inclusion criteria. Additional information contained in the survey regarding average alcohol use and medications was used as the screening measure (see "Sample" and "Ethical Considerations" in this

Chapter). The present research employed a randomised experimental design using repeated measures (test-retest) to obtain baseline measurements and experimental measurements on the Automated Working Memory Assessment. A single administration of the Raven's Progressive Matrices (Standard Form) (RPM) during the same session as the baseline AWMA administration. A planned minimum three-week delay was designed for implementation between the assessment sessions (Anastasi & Urbina, 1997). During the experimental assessment of the AWMA subtests, repeated measures of Breath Alcohol Concentration (BAC) and measurements on the Brief Biphasic Alcohol Effects Scale (B-BAES) were taken prior to the full assessment and before each subtest of the AWMA. The demographic information, together with BAC, B-BAES and intelligence scores, was retained as both descriptive variables and the potential covariates. The following sections further discuss sampling strategies, the data collection protocol, the procedure utilised, ethical considerations and the foundation of the data analyses.

Procedure

This study followed a controlled experimental procedure, but some exploratory components were included in the data analyses based on information emerging during the process (see Chapter 6, "Results"). Following invitation to participate, participants underwent assessment on the Raven's Progressive Matrices (Standard Form) and Automated Working Memory Assessment (Long Form). A delay of a minimum of three-weeks was required, followed by the experimental assessment on the AWMA in combination with the Brief Biphasic Alcohol Effects Scale (B-BAES). The B-BAES was administered prior to each subtest after which the breath alcohol readings were taken using a standard breathalyser. All data collection was conducted by the researcher who had been trained in the use of the instruments and associated equipment such as computer programmes. All assessments and interactions were conducted in English and ensuring understanding of instructions was paramount. No participant reported misunderstanding of instructions due to language factors nor was this observed by the administrator.

Following initial contact and collection of demographic and screening information, participants presented themselves for a baseline assessment of approximately two to three hours at a mutually convenient time and location. The location used was quiet and as free of distractions as possible. The informed consent document was signed prior to the baseline assessment session beginning (see "Ethical Issues"). All possible measures and actions were taken to place the participants at their ease and in a state of sufficient relaxation to perform as

well as possible on the assessments. The first assessment consisted of the Raven's Progressive Matrices (Standard Form) and the Automated Working Memory Assessment in that order with a short break in between.

The Ravens Progressive Matrices (Standard Form) was administered according to the instructions presented in the manual (Raven et al., 2000). Participants were provided with an explanation of the assessment and its purpose. Participants were assured that the assessment would be conducted for research purposes, specifically as an indication of how their non-verbal pattern reasoning might relate to the other assessments used in the research. As per the manual, the first two items were completed on the standard answer sheet with the administrator's assistance. Items were marked with pencil as the selection of the desired multiple-choice option. Participants were encouraged to ask questions if they did not understand what was required of them as full understanding and performance on the assessment was deemed more important than the ability to infer or deduce requirements. No participants required clarification. Participants were informed that they would be timed on the assessment but that there was no time limit for the completion of each item or the full assessment and were encouraged to work carefully without concerns about the time they had taken. At completion of the assessment, the time taken was noted on the answer sheet for later inclusion in the study's data set. Points of partial completion of the assessment at the 20-minute mark were not conducted as the manual indicated these were primarily to be used diagnostically. Completion times ranged between 18.00 and 53.00 minutes with a mean time of 30.56 minutes for completion of the full instrument (M = 30.56, var = 139.06, SD = 11.79). Half of the participants (n = 8, 50.00%) completed the full assessment in approximately 20 minutes with a further 4 (25.00%) completing in approximately 40 minutes and the remaining four participants being spread across the range of values. Once participants had completed the RPM, they were asked if they required a brief break. None requested a break of more than approximately 5 minutes. The administration of the AWMA then proceeded.

The AWMA was administered on a Toshiba laptop with a 15.6" inch screen. An additional USB keyboard and mouse were attached for use by the administrator to ensure the participants were given sufficient personal space for comfort. In addition, the distance of the keyboard from the computer allowed for more discrete marking protocol using the left and right keys for incorrect and correct answers respectively as per the assessment software requirements. The AWMA, described in "Instruments", is a computerised assessment but participants are not required to interact with the computer directly. Some participants were unsure about using a computer but regained relaxation after assurances that they were not

required to type or do any other activity and that the computer was simply a visual and auditory tool. Participants were not informed of how the actual marking (pressing of arrow keys) was done to ensure fewer distractions or concerns. For the baseline assessment, the subtests were conducted in the standard order. Since the primary focus was maximum performance ability, participants were given as much time as was needed to understand the examples and any additional explanations or guidance were given freely. Before starting the assessment, participants confirmed that they had a full grasp of what was required, were comfortable in their position, could see the screen clearly and that the volume of the speakers was sufficient.

As discussed in "Instruments", the AWMA subtests progress in sets of increasing numbers of items, starting with one item to remember, or two in the case of the backwards-digits assessment, and proceeding numerically. The participants began each set or level matching the number of items presented in the final example unless performance and understanding appeared strained. In two cases, on the Mister X and Spatial Recall assessments, a reduction to level one was required followed by normal performance following the additional practice. In these two cases, additional familiarity or practice was required. Following completion of the assessments, participants were thanked and a tentative date for the next assessment was set. Participants received an explanation of what the next assessment would entail.

The delay between assessments was implemented at a hypothesised minimum of three-weeks (Anastasi & Urbina, 1997) but the minimum delay implemented in practice was four-weeks. Repetitive assessments may be subject to practice effects which may cause an artificial adjustment in test scores due to familiarity with items on the assessment (Lo et al., 2012). This complication has posed difficulties in a variety of other studies which attempted to establish differences in test scores following the administration of alcohol, as well as those which attempted to study the impact of alcohol at different points on the BAC curve (Pihl et al., 2003). Studies utilising neuropsychological measures have indicated non-significant, but present, practice effects following a three-week delay after initial testing (Gastaldo, Reeves, Levinson, & Wenger, 1997; Levinson & Reeves, 1996). Due to practicality concerns, a specific assessment delay was not feasible and the precise delays exceeding three-weeks between assessments did vary between participants. In the present research, the varying delays resulted in the use of the test-retest delay variable as a potential covariate to control for any influence on the findings. This is addressed in Chapter 7 in the sections "Discussion and Findings" and "Strengths and Limitations".

The shortest delay between assessments was 28 days whilst the longest delay was 213 days resulting in a mean delay of 87.38 days (*SD* = 52.59 days) and a median delay of 74.50 days. Approximately 75.00% of the sample underwent both assessments within 100 days. Similarly, 50.00% of the total sample completed both assessments in 73 days or less. Examining only this 75.00% of the sample (*n* = 12) produced a mean delay of 62.25 days and a dispersion figure of approximately half that of the full sample (*SD* = 22.64 days). Following the delay, the participants underwent the experimental component of the assessment.

The date and time of the experimental assessment was arranged at the participant's convenience. All experimental assessments were undertaken in the same venue and under the same conditions as the baseline assessments. Time of day did differ but efforts were made to arrange the assessment during the middle portion of the day. Participants were requested to eat a small meal approximately two hours prior to the assessment, to refrain from heavy exercise and the consumption of any high sugar products, caffeine or alcohol. These instructions were intended to ensure the absence of any activities which may have altered cognitive or metabolic functions. Once participants arrived at the assessment venue, confirmation of compliance with these instructions was sought. No deviations were expressed and all participants indicated feeling comfortable without undue hunger or difficulties from any change in normal routine. The experimental assessment session was conducted with a specific protocol and sequence to ensure standardisation across participants and the most reliable results possible.

It was explained to participants that they were asked to consume an alcoholic beverage within a set time, would have breathalyser readings taken, would be asked to indicate their feelings of congruence with some words and would perform on the AWMA again. The focus of the instructions was full understanding in a relaxed environment, not standardised dialogue. Prior to beginning the assessment, participants were introduced to the breathalyser and how it worked using several "practice" readings which also confirmed the required 0.00 BAC reading prior to the assessment. The B-BAES was also introduced and explained, allowing the opportunity for requests for clarity on the meaning of any of the six words or how the scale of measurement was expressed. The first assessment on the B-BAES was conducted prior to beginning the formal assessment and marked using paper/pencil protocols by the researcher. The participants were encouraged not to belabour their assessment of their feelings of congruence but to rather express their immediate feeling. The alcoholic beverage was then administered.

The alcoholic beverage consisted of 40 millilitres of Smirnoff triple distilled vodka containing 43% alcohol by volume combined with 200 millilitres of Schweppes Tonic Water

producing a total of approximately 13.6 grams, or 17.2 ml, of ethyl alcohol. One unit of alcohol is generally defined as a 'standard drink' or 10g of ethyl alcohol calculated by percentage proof of the spirit to be ingested (Department of Mental Health and Substance Dependence: Noncommunicable Diseases and Mental Health Cluster, 2000). When participants arrived the two components of the beverage were on the table. After participants rated their congruence with the words on the B-BAES scale, the drink was measured and poured in plain view. The bottle of alcohol remained on the table throughout the assessment. This was intended to increase the ecological validity of the study through simulation of an average situation in which participants may consume alcoholic beverages, for example, a bottle of wine on the dinner table.

Participants were given 10 minutes to consume the beverage and all participants consumed the beverage well within this time limit without excessive speed. Following complete consumption of the beverage, a further five-minute delay was implemented to ensure residual alcohol did not remain in the mouth which would elevate BAC readings. Once the five minutes had lapsed, the first breathalyser reading was taken using a CE certificate and calibrated standard breath alcohol detector accurate to two decimal points of percentage breath alcohol levels over 1000 readings. If the BAC readings appeared abnormally high (≥ 0.04), the participant was asked to take a few small sips of water to ensure that residual alcohol in the mouth was not influencing the readings and a confirmatory reading was taken. The assessments were conducted with BAC readings prior to each of the twelve AWMA subtests and a final reading after the conclusion of the assessment. The B-BAES ratings were taking pre-alcohol administration and before each subtest as well as a post-test rating. The order of administration was standardised as: 1) B-BAES; 2) BAC reading; and 3) commencement of the AWMA subtest. The order of the subtests for the experimental assessment was randomised in advance to ensure sufficient variation in readings across the full assessment.

The randomisation of the AWMA subtests for ordering during the experimental assessment was done via the generation of a random number table with the appropriate limits (1-12) in the open-source package R. A new table was generated for each participant. No single assessment appeared more than four times in the same position. Chi-squared tests of frequency of the positions did not show any statistically significant differences in the counts of each assessment in each position ($\chi^2 = 127.50$, $df = 121$, $p = .325$). Due to the importance of appropriate randomisation given the instability of BAC readings over time due to natural metabolism, further analysis using the Fisher exact test was conducted for confirmation. Fisher's exact test is often appropriate in situations where expected frequencies of less than

two exist, as was quite possible in the present research where sixteen participants and twelve subtests were used (Hair, Anderson, & Tatham, 1987; West & Hankin, 2008). Expanding upon this issue, the Monte Carlo bootstrapping method was used to derive random samples of the specified size (Hoyle, 1999). No statistically significant probability values (two-sided, $\alpha = .05$) were obtained for theoretical samples of tables, based on the observed values, using 10 000 sampled tables (*Fisher* = 110.62, $p = .240$), 1000 sampled tables (*Fisher* = 110.62, $p = .240$) or 100 sampled tables (*Fisher* = 110.62, $p = .180$). The lack of statistical significance in these analyses confirmed the effective randomisation of the twelve subtests during the experimental assessment protocol.

The AWMA subtest procedure under the experimental condition was conducted in the same manner as in the baseline condition with exception of the addition of the B-BAES and BAC readings. Following the completion of the full assessment and final post-assessment readings, participants remained in the venue until a BAC reading compliant with the legal limit for the operation of a motor vehicle (0.02). During this period, or directly after the assessments if no waiting period was necessary, basic refreshments were provided and participants were given the opportunity to request debriefings on the procedure. To facilitate this process, the researcher queried how the procedure was experienced individually and prompted for questions. No notable responses were given. This concluded the research activities for the participant and the commencement of the data management process.

Data Collection, Manipulation and Management

Data Collection and Capture Procedures

Screening questionnaire data was obtained either electronically via SurveyMonkey or paper/pencil and stored electronically as item responses. The psychometric assessments were administered, scored and captured in accordance with their respective manuals and literature (Alloway, 2007; Raven et al., 2000; Rueger & King, 2013). Norms, based on age, and percentile scores for the AWMA assessment are also automatically calculated using these norm groups (Alloway, 2007). However, since age was controlled for by the repeated measures (test-retest) method in the present research the raw AWMA scores were used for analysis while the normed percentile scores were for noting only. The AWMA scores were recorded electronically and the full interpretive reports were also drawn and saved electronically. The Raven's Progressive Matrices (Standard Form) age-based norms, as per the manual, were made use of for recording purposes only (Raven et al., 2000). The RPM was scored and interpreted

in hard copy and the raw scores were entered and recorded electronically in the data set. Data was kept in spreadsheet format for appropriate coding and labelling as an excel file then, later, SPSS file (see below). Original files, answer sheets and copies were stored. The researcher conducted all scoring, coding, transfer and storage as well as later manipulation. Data was stored appropriately, correctly and securely in line with relevant legislation (e.g. Health Professions Act no. 56, 1974).

Data Cleaning, Pre-Analysis Manipulation and Storage Procedures

Data was captured, stored and coded in spreadsheet format in preparation for transfer to IBM SPSS Statistics® version 24 (SPSS) for analysis. Nominal (categorical) variables were coded numerically through conversion of text-based responses to numerical codes and labelled. Prior to transfer to SPSS, the variables age (in years based on date of birth and date of first assessment) and body mass index were calculated via a formula. Scale (interval) variables were specified at two or three decimal points if required and applicable. Test order in the experimental condition was regarded as numerical positions.

Progressive saving protocol for versions of the data set was implemented if any substantial changes to coding or structure were made to ensure reduced risks of corrupted data or missing data. Personal details and identifiers were retained for reference or correction to cases if required. Identification of potential typographical or coding errors was undertaken through the generation of frequency distributions for each variable. Each variable was checked for the full sample size, correct range of possible values and missing values. No corrections were required. During the data integrity check, a brief examination for valid outliers was conducted. Single values which appeared considerably different were confirmed by examination of original records. No corrections were required.

All data was stored securely in paper and electronic formats in line with the Health Professions Council of South Africa guidelines and the Health Professions Act no. 56 (1974) guidelines and requirements. Data will be stored for a minimum of ten years. Participants were informed that they may request their results, and feedback, but none elected to participate in this process. Should a copy of the data sets be requested for any legal and acceptable official purposes, an anonymised version will be saved, stored and provided as necessary.

Ethical Considerations and Compliance

Various ethical issues were present in this research. Ethical clearance for the study was obtained from the University of the Witwatersrand Medical Human Research Ethics

Committee (Appendix A). Some factors and actions were related to moral considerations, some to Health Professions Council of South Africa (General and Psychology) and legislatively governed guidelines (e.g. Health Professions Act no. 56, 1974) and requirements and others to specific requirements laid out by the Medical Human Research Ethics Committee (HREC) of the University of the Witwatersrand prior commencement of the study. All data was gathered either via electronic media on password protected system or in person by the researcher. Correspondence via secure e-mails remained on record and data noted in this way was kept as minimal as possible for security and privacy reasons. As explained in the "Sample" section of the present Chapter, exclusion criteria were implemented. These criteria, required and mandated by various sources, were derived from the screening questionnaire and later communications if required. Females were excluded from participating due to the risk of unknown pregnancy. For health and safety reasons, participants were required to drink alcohol at least once per week, be free of any mental or physical disorders precluding the consumption of alcoholic beverages (e.g. severe depression, diabetes), not to be frequently engaging in excessive binge drinking, be free of any criminal record per self-report and to never have been diagnosed with, or suspected, a drug or alcohol abuse disorder per self-report. Since the researcher relied on self-report for participants to be considered to have fulfilled these criteria, the possibility of false information being provided and leading to inclusion did exist. However, since the study did not carry incentives for participants, and the exclusion criteria were known beforehand, it is unlikely that participants misrepresented themselves intentionally to ensure inclusion.

In addition to the self-report intrinsic exclusion criteria based on participant history, specific characteristics were deemed important. According to commonly known legislation, no individual under the age of 18 years is permitted to drink alcohol. The HREC determined that this age be increased to 21 years as a minimum limit for inclusion in the research to ensure adequate maturity to comprehend the risks associated with drinking alcohol and understand the implications of participation in voluntary research. Furthermore, although they may have fallen into the specified age bracket, current pre- or post-graduate students were not permitted to participate due to inherent vulnerability based on factors of perceived power and authority and comprehension of research. This criterion was implemented to avoid undue, and unintentional, coercion.

Declarations of honesty were checked during the online questionnaire and signed on paper, along with the informed consent document, at the commencement of the baseline measurement session. The declarations confirmed that the information provided in the

screening questionnaire was accurate. An informed consent document was signed at the commencement of the baseline measurement session. The document was written in English and explained and discussed verbally as required. Informed consent outlined agreement to participate in the full project, the required activities, the inherent risks of consuming alcohol, options and assistance in the eventuality of requiring medical or psychological services due to participating in the project and understanding of the necessity of ensuring that they were not permitted to leave the venue after the experimental assessment without meeting the approved breath alcohol level requirements. The document also confirmed their freedom to withdraw from the study at any time without adverse consequences and that they were participating in the research voluntarily without incentive or coercion. During the assessments, only the researcher conducted assessment in accordance with the instructions presented in the assessment manuals. The researcher is appropriately qualified, registered and familiar with the assessments used. The data generated from these assessments was carefully processed and stored in line with Health Professions Council of South Africa guidelines and requirements, the Health Professions Act no. 56 of 1974 requirements and the requirements of the Protection of Personal Information (PoPI) Act no. 4 of 2013 and the HREC of the University of the Witwatersrand.

Participant identifying details were retained in the data set for the purposes of capture and collation, or later contact. Only information essential to the research was gathered. Hard copies were captured electronically in the data set and stored in line with the various requirements. All electronic records were appropriately named and stored on a password protected computer which is privately stored. Participants were not able to see the identifying information or any other details about other participants at any point. Only information pertaining directly to the participant at the session was present during each session except for cases where more than one session was taking place in a single venue on the same day. In such cases, non-applicable information was kept out of sight. Care and storage of the data remains the responsibility of the researchers. All information remains confidential following collection and for the upcoming mandated storage period. Should the data sets be required for any other purposes, or sharing with a supervisor or committee be required, all identifying personal and contact information excepting that which is necessary for further analysis of the data set will be removed. No hard copies of data will be distributed (including test item responses) without compelling legal cause. In such cases, all identifying information will be removed and a copy of the information will be distributed unless the originals with identifying information are legally required via appropriate processes.

Data was only used for the express purposes of the research project. Any further uses will only be permitted if directly related to replicating the findings or required by legislation for proceedings. Following publication of the research findings, data will only remain in storage but may be used for continued analyses directly related to this research and within the confines of the project and dependent on granted ethical approval. If any projects using this data are planned which fall outside of this scope, the process of a second HREC approval would be applied for and participants would be contacted to obtain a second informed consent for the use of the data gathered. Participants may, at any time, request confirmation of their data stored by the researcher, request amendments or request deletions of their information. Participants may also contact the researcher and be provided with an express outline of how their information has, and will, be used and reserve the right to decline use of the information in such a manner.

Data Analyses

The scale variables were analysed for distribution and normality first using standard measures of range and dispersion, including minimum and maximum values, means, standard deviations, variances and standard errors. Statistics of skewness and kurtosis, and associated standard errors, were utilised to provide a preliminary indication of the normality of the distribution of the scale variables based purely on the variability of the known sample around the sample mean, median and mode (Howitt & Cramer, 2011; Rosenthal & Rosnow, 2008). Several measures for the assessment of normality and inferential protocols were conducted. In all cases probability levels were set at $\alpha = .05$ for statistical significance and $\alpha = .08$ for approaching statistical significance as an estimate. Issues of effect sizes were related to this approximation and are discussed later in this section.

Parametric statistical assessment requires an acceptable level of normality of distribution (Ho, 2006). However, values of skewness and kurtosis provide limited information based only on the commonly used range of -1.000 to +1.000 indicative of normality of distribution based on the calculation of normalised *z*-scores from the sample (Huck, 2009; Ghasemi & Zahediasl, 2012; Rosenthal & Rosnow, 2008). Therefore, the Kolmogorov-Smirnov and Shapiro-Wilk tests were used for formal assessment of the normality of the distributions. Statistically significant values indicate a deviation from the expected normal distribution, implying a violation of the assumption of normality of distribution (Howitt & Cramer, 2011). The Kolmogorov-Smirnov test of normality is the most commonly used and is based on vertical distances between the known sample and hypothetical normal distribution,

however, the statistic is sometimes considered too conservative presenting with larger incidences of Type I errors (Lilliefors, 1967; Razali & Wah, Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests, 2011). The Shapiro-Wilk values, dependent on a covariance matrix rather than distances, appears to be robust for small sample sizes (Shapiro & Wilk, 1965) although Lilliefors (1967) cautions that the Type I errors noted for the Kolmogorov-Smirnov test are not necessarily due to challenges with sample sizes. For the present research, both are reported for comparative purposes.

Pearson's *r* and Spearman's rho (ρ) correlation coefficients were calculated in the assessment of scale variables for the demographic, lifestyle, BAC readings and psychometric assessment results. This applied even if a limited range of responses was present, as for some of the lifestyle variables. Aside from preliminary assessment of the demographic variables, correlation coefficients were used to calculate associations between the baseline and experimental measurements on the AWMA subtests as well as between the RPM and the baseline AWMA scores for the assessment of that relationship. Furthermore, as noted below regarding repeated measures analysis of covariance, the explorations of the interactions between the covariates and the differences between the repeated measures subtests was required. Correlation coefficients were calculated between the difference scores from the baseline to the experimental measurements on the AWMA and the covariates participant age, the RPM, test-retest delay, average BAC levels and the derived "Stimulated" scale.

Pearson's *r* and Spearman's rho are both dependent upon covariance between the sets of scores which can create challenges in circumstances where sample sizes are small and ranges of scores are limited due to measurement or other reasons. Spearman's rho initially ranks the variables in ascending order, breaking tied ranks and effectively increasing the range of responses available to compute covariance values from calculating the coefficient (Howitt & Cramer, 2011; Huck, 2009; Rosenthal & Rosnow, 2008). The confidence intervals represent the 95% likelihood of the correlation falling within the upper and lower limits of the interval (Rosenthal & Rosnow, 2008). In most cases in the present research both coefficients are reported for full understanding of the linear relationships in the data.

To examine the basic differences between the repeated measures, repeated measures analysis of variance models were calculated. The repeated measures analysis of variance permits the individuals in the sample to act as their own control, essentially comparing the means of two identical groups within one sample, thus eliminating between-group differences which may confound the findings. In this way, the procedure also assists in mitigating challenges with small sample size research, particularly regarding issues around covariance,

by accounting for the linear correlation over the repeated measures (Detry & Ma, 2016; Ho, 2006; Howitt & Cramer, 2011; Huck, 2009; Littell, Henry, & Ammerman, 1998; Rosenthal & Rosnow, 2008). Although some have questioned the reliability of differences scores used in a repeated measures model, they do reduce the error terms of the statistics thereby increasing the power of the statistics. Therefore, this index of measurement is becoming increasingly popular and well-studied, particularly in longitudinal research in the health sciences in which obtaining large samples and multiple groups can be challenging (Howitt & Cramer, 2011; May & Hittner, 2004; Thomas & Zumbo, 2012).

By way of comparison for the simple comparisons, matched-pairs *t*-tests, another repeated measure correlated scores design which produces the same statistic as *F* in the analysis of variance, were conducted with bias corrected accelerated (BCa) ($B = 1000$) bootstrapping. The Monte Carlo repeated sampling simulation used in bootstrapping allows for the increase of the sample size, thus producing not only a statistic, but also an estimate of bias. The bias estimate, when large, suggests an unreliability of the sample statistic (Hoyle, 1999). More complex repeated measures analyses studies were conducted inclusive of covariates as repeated measures analyses of covariance models, also discussed as general linear models. These analyses included both the model statistics, primarily as comparisons and evaluations of *F* and partial eta squared, as well as interactions between the covariate and the differences within the model, providing an indication of the importance and action of the covariate(s) used. The interactions were also assessed via Pearson's *r* and Spearman's rho correlation coefficients and linear models.

The repeated measures analysis of covariance relies on the same principles discussed regarding the normal repeated measures analysis of variance but is also calculated as a general linear model (GLM) in SPSS linearly removing the influence of covariate(s) from the calculation of the repeated measures differences. The role of the covariate(s) can be expressed as a regression model in the case of a single covariate or multiple regression model in the case of several covariates (Ho, 2006). Therefore, comparison of the various models controlling for the influence of one, or more, covariates, allowed the assessment of the repeated measures differences whilst the interactions allowed for the assessment of the roles of the covariate(s) with, or without, the influence of the other covariate(s) (Ho, 2006). The interactions in a repeated measures analysis of covariance model are equivalent to the regression lines in a general linear model between the covariate and the difference score on the repeated measures, making regression models a viable alternative, or valuable adjunct, to the repeated measures model (Lininger, Spybrook, & Cheatham, 2015). Therefore, the interaction provides an

indication of the power of the covariate in predicting the repeated measures differences whilst still accounting for other covariates as a multiple regression model (Hair et al., 1987; Rosenthal & Rosnow, 2008).

Since average BAC was considered the variable of primary interest, in addition to the actions of the covariates in the model, the influence of covariates associated with average BAC on the relationship between the difference score and average BAC was of importance. For this assessment, first order partial correlation coefficients were used as a standardised calculation to remove the influence of the alternate covariate from the relationship between average BAC and the subtest differences by interpreting the correlation between the residuals only (de la Fuente, Bing, Hoeschele, & Mendes, 2004; Ho, 2006; Howitt & Cramer, 2011; Lipsitz, Leong, Ibrahim, & Lipshultz, 2001; Rosenthal & Rosnow, 2008). These were compared for consistency with the semi-partial correlation coefficients, also known as part correlation coefficients, removing the influence of the alternate covariate from the average BAC variable alone in its association with the subtest difference score. Congruence between the two confirmed the supposition of the influence of the alternate covariate as being on average BAC alone, or both average BAC and the subtest differences.

Aside from the comparison models, and associated probability values, effect sizes within the models were deemed important due to the likelihood of small sample sizes decreasing the probability value due to the nature of *F* being a product of the multiplicand of the effect size and sample size (Rosenthal & Rosnow, 2008). The use of effect sizes has been increasing in the behavioural sciences research field (Fritz, Morris, & Richler, 2012) and Rosenthal and Rosnow (2008) have argued for the use of statistical effect size over probability values to mitigate the many potential influences significance levels are subject to. However, the effective reporting of effect sizes is also challenging.

Statistically, for an analysis of variance, partial eta squared is the common calculated effect size for both between-group and within-group analysis of variance studies (Bakeman, 2005; Fritz et al., 2012; Howitt & Cramer, 2011; Huck, 2009; Rosenthal & Rosnow, 2008). For the partial eta squared statistic in analysis of variance, classifications of small (≤ .010), medium (± .060) and large (≥ .140) exist. In linear regression models, a more substantial value is required for small (≤ .020), medium (± .130) or large (≥ .260) sizes (Cohen, 1988). Care is required as a strict threshold of usefulness is not always possible and has not been agreed upon (Fritz et al., 2012; Richardson, 2011). Bakeman (2005) and Ferguson (2009) both suggested reporting systems comparing effect sizes to those of similar studies. However, comparisons are not always practical, or feasible, due to discrepancies in methodologies and failure to

comprehensively report effect sizes in publications (Fritz et al., 2012). Therefore, it is advisable that other information must be considered for reporting and interpretation purposes to provide context to the reader.

As suggested by Fritz et al. (2012) in their paper on effect sizes in the social sciences, effect size along with other information regarding the calculations, such as the sum of squares, degrees of freedom and reported power, provides context to the reader in the interpretation of the findings. Since the use of effect sizes over probability values is intended to reduce the influence of potential for Type I and Type II error, reporting in conjunction with power levels $(1 - \beta)$ is certainly desirable to provide context in interpretation. Power levels of .800 and over, in association with medium or large effect sizes, provide a good indication of the true differences in the population parameters free of the weaknesses the probability value is subject to (Cohen, A power primer, 1992). However, partial eta squared is subject to its own limitations such as potential for overestimation, challenges in accuracy in designs where measures are not appropriately standardised, non-random sampling and being susceptible to the influence of multiple covariates (Ferguson, 2009; Fritz et al., 2012; Levine & Hullett, 2002). Acknowledgement of these weaknesses in the study design is important and effect sizes are perhaps best interpreted in the context of additional information and known assumptions (Vacha-Haase & Thompson, 2004). The next chapter describes the results of the analyses and reports the associated statistics.

Chapter 6

Results

Preliminary Analysis of the Variables: Normality and Distribution

This chapter presents the results of the descriptive and inferential analysis carried out in the study. A description of the differences in the findings based on demographic and lifestyle variables is presented. Following the descriptive findings, the inferential comparisons of the pre-test and post-test findings on the AWMA are presented with details. Further analyses are introduced and discussed throughout the text. The analyses were conducted utilising the IBM SPSS® 24 package.

Demographic and Lifestyle Variables

Participant's age, height, weight, body mass index (BMI), exercise levels and drinking behaviours were recorded. The demographic and lifestyle variables were analysed for their influence on breath alcohol levels and subjective intoxication. The analyses were used to assess the necessity of their inclusion, or exclusion, as covariates in the inferential models. Table 17 shows the distribution characteristics of the demographic variables.

Commonly, a range of 1.00 to -1.00 for skewness and kurtosis is deemed as a presentation of data close to a normal distribution although this standard is poorly explained in most texts (Rosenthal & Rosnow, 2008). Table 17 shows the dispersion in age throughout the limiting range of 21 years to 35 years. The values of dispersion (*var* = 10.752, *SD* = 3.280) indicate good spread of the data whilst the values for skewness and kurtosis were an acceptable 0.223 (*SE* = 0.564) and -1.123 (*SE* = 1.091) respectively. The height of participants had large variability statistics (*var* = 109.717, *SD* = 10.475, *SE* = 2.619), as did the measurements of weight (*var* = 175.862, *SD* = 13.261, *SE* = 3.315). Aside from an abnormally platykurtic distribution for weight was calculated (*kurtosis* = -1.246, SE_{Kurtosis} = 1.091), the values of skewness and kurtosis were within normal bounds for all the demographic variables. Examination of tests of fit for normality, in this case the Kolmogorov-Smirnov and Shapiro-Wilks values, can be more useful in understanding the adherence of sample data to the assumptions of normality mentioned by most texts (Rosenthal & Rosnow, 2008). The distribution values reported are depicted graphically in the following figures and tables.

Table 17

Tests of normality of demographic variables: Age, Height, Weight and Body Mass Index (n = 16)

	Range			*Dispersion*			*Normality*				*Tests of normality*			
	Min	*M*	*Max*	*Var*	*SD*	*SE*	*Skewness*	$SE_{Skewness}$	*Kurtosis*	$SE_{Kurtosis}$	*Kolmogorov-Smirnov*	*p*	*Shapiro-Wilk*	*p*
Age (Years)	21.16	25.72	31.13	10.752	3.280	0.279	0.223	0.564	-1.123	1.091	0.152	.200	0.944	.403
Height (cm)	160.00	176.38	195.00	109.717	10.475	2.619	-0.163	0.564	-0.398	1.091	0.193	.972	0.927	.218
Weight (kg)	54.00	70.56	92.00	175.862	13.261	3.315	0.631	0.564	-1.246	1.091	0.225	.030*	0.859	.018*
BMI (Points)	18.51	22.60	29.39	10.144	3.185	0.796	0.819	0.564	-0.157	1.091	0.182	.163	0.926	.207

*Significant at the 5% level

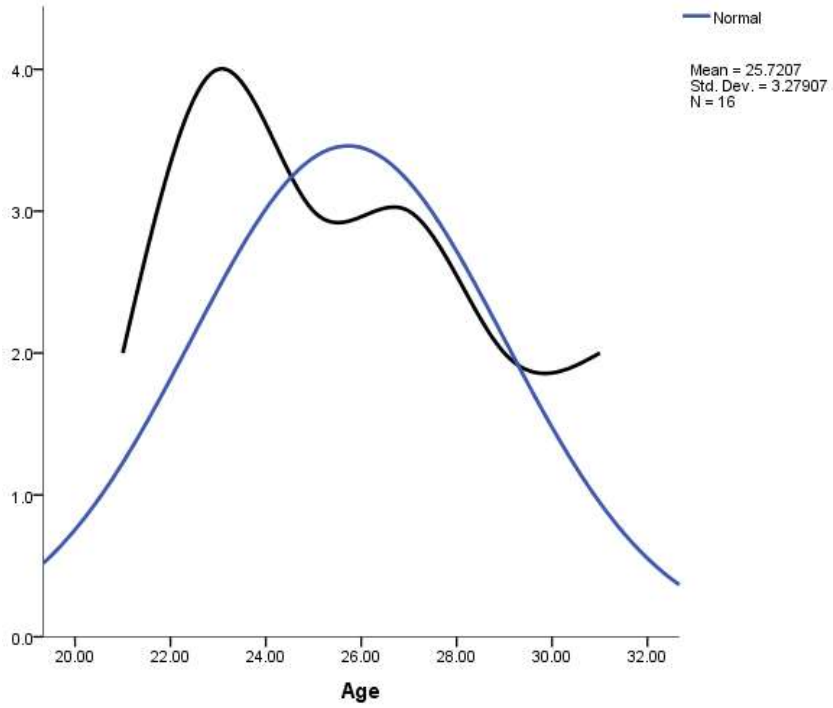


Figure 17. Sample distribution of the demographic variable "Age" (n = 16)

Participant age was normally distributed based on the Kolmogorov-Smirnov (K-S = 0.152, p = .200) and Shapiro-Wilk statistics (S-W = 0.944, p = .403). Figure 18 shows the statistics for height.

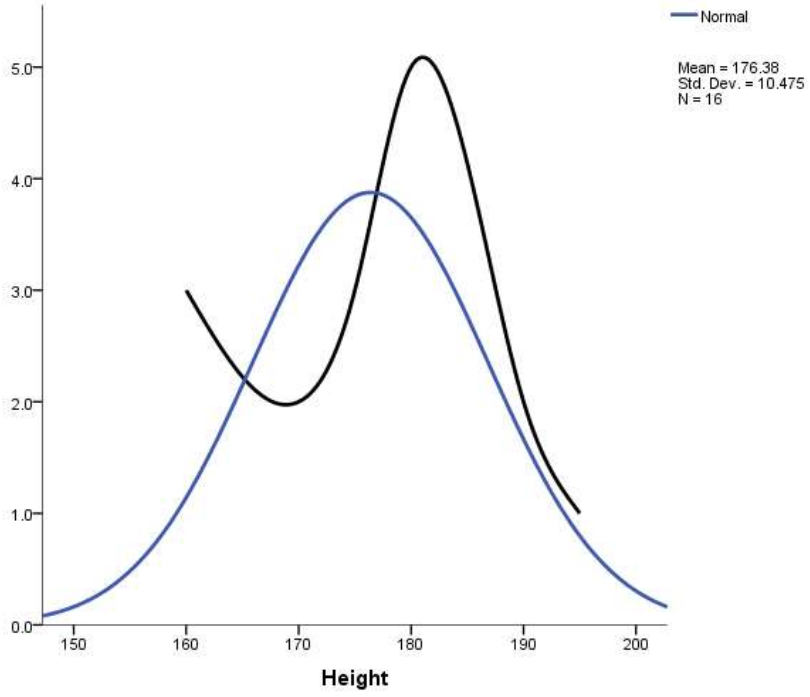


Figure 18. Sample distribution of the demographic variable "Height" (n = 16)

Participant height was shown to be normally distributed (*K-S* = 0.193, *p* = .972). Despite not achieving statistical significance, the Shapiro-Wilk statistic did differ considerably in comparison to the Kolmogorov-Smirnov statistic (*S-W* = 0.927, *p* = .218). Participant weight, on the other hand, did differ statistically significantly (*p* < .05) from the normal distribution.

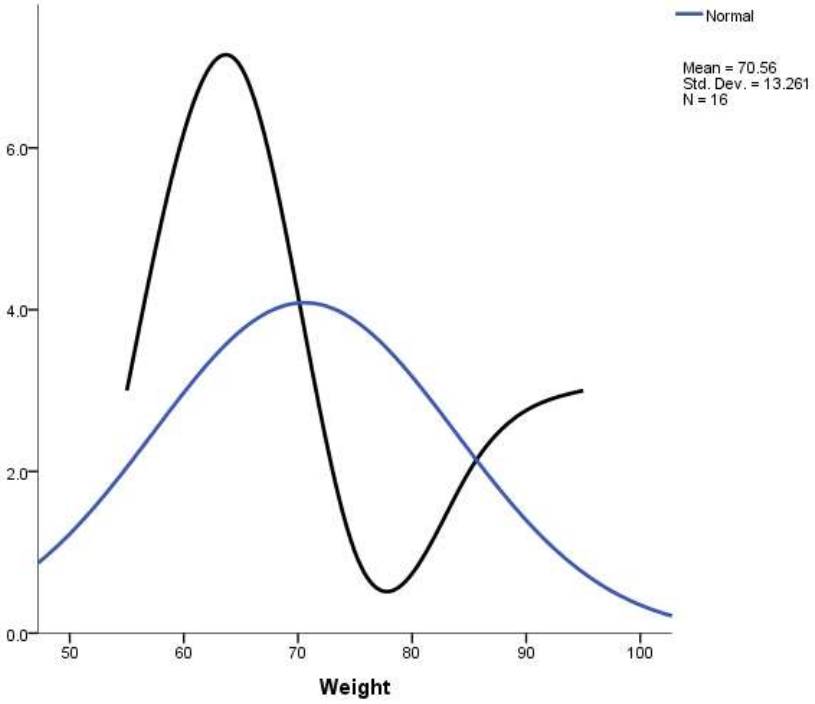


Figure 19. Sample distribution of the demographic variable "Weight" (*n* = 16)

Participant weights were truncated towards the left side of the distribution, most probably due to the influence of a small number of cases exhibiting higher weights. The distribution differed significantly from normal (*K-S* = 0.225, *p* = .030). A similar statistic, and probability value, was calculated for the Shapiro-Wilk test (*S-W* = 0.859, *p* = .018). Figure 20 shows the distribution.

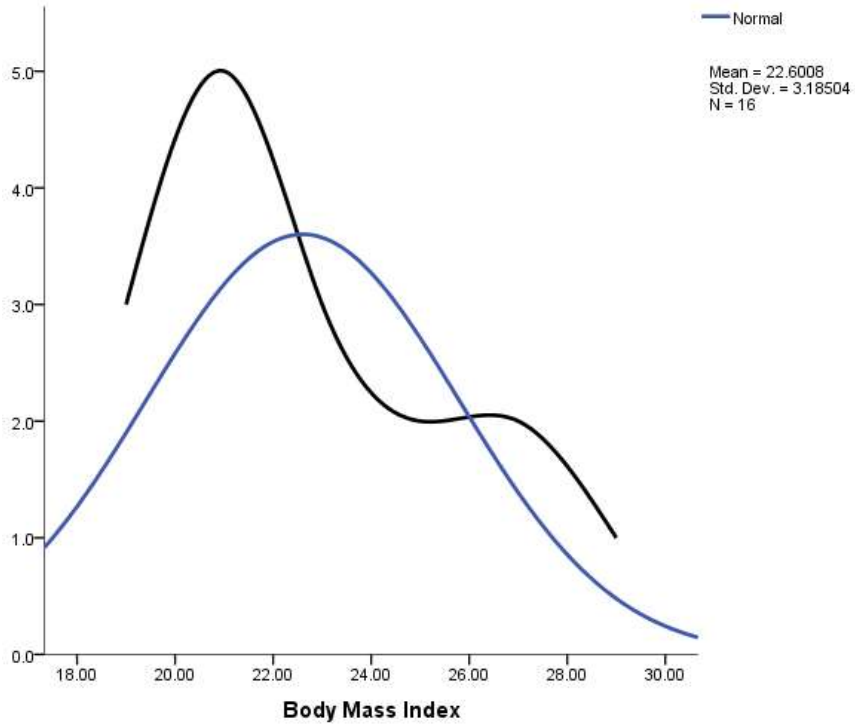


Figure 20. Sample distribution of the demographic variable "Body Mass Index" (n = 16)

As shown in Figure 20, body mass index was normally distributed based on the Kolmogorov-Smirnov statistic (K-S = 0.182, p = .163) and Shapiro-Wilk statistic (S-W = 0.926, p = .207). The remaining demographic variables, including drinking behaviours, were assessed categorically in relation to the outcomes of breath alcohol concentration and the Brief Biphasic Alcohol Effects Scale (B-BAES). Since the variables were ordinal in nature and some were subject to exclusion criteria during the sampling process, assessment of their distribution's normality was not useful.

Breath Alcohol Concentrations

As discussed in the "Procedure" section of the "Methods" chapter, a standard breathalyser was used to obtain BAC readings throughout the testing procedure. Readings were taken prior to each subtest and post-assessment resulting in a total of thirteen values per person. Discussions around the curve of BAC values have demonstrated a swift rise followed by tapering off in the form of a positively skewed distribution. This would be considered "normal" for the purposes of this research. Further information and references in this regard can be viewed in Chapter 3 regarding the impact of alcohol. This section will describe the distribution and values of dispersion of the BAC readings. Table 18 shows the range, dispersion, skewness and kurtosis of the thirteen BAC readings.

Table 18

Range, Dispersion, Skewness and Kurtosis of the BAC Assessment Points (n = 16)

	Dispersion				*Skewness*		*Kurtosis*	
	max	*M*	*SE*	*SD*	*Statistic*	*SE*	*Statistic*	*SE*
BAC Subtest 1	0.08	0.03	0.01	0.02	0.629	0.564	1.258	1.091
BAC Subtest 2	0.06	0.02	0.00	0.02	1.047	0.564	0.834	1.091
BAC Subtest 3	0.04	0.02	0.00	0.02	0.470	0.564	-1.063	1.091
BAC Subtest 4	0.04	0.02	0.00	0.02	0.615	0.564	-1.062	1.091
BAC Subtest 5	0.05	0.02	0.00	0.02	0.577	0.564	-1.036	1.091
BAC Subtest 6	0.04	0.01	0.00	0.02	0.343	0.564	-1.654	1.091
BAC Subtest 7	0.04	0.01	0.00	0.01	0.732	0.564	-1.005	1.091
BAC Subtest 8	0.04	0.01	0.00	0.01	0.835	0.564	-0.576	1.091
BAC Subtest 9	0.03	0.01	0.00	0.01	0.820	0.564	-0.823	1.091
BAC Subtest 10	0.03	0.01	0.00	0.01	0.947	0.564	-0.718	1.091
BAC Subtest 11	0.03	0.01	0.00	0.01	1.416	0.564	1.099	1.091
BAC Subtest 12	0.02	0.00	0.00	0.01	1.433	0.564	0.783	1.091
BAC Post-test	0.02	0.00	0.00	0.01	1.890	0.564	3.035	1.091
BAC Average*	0.040	0.013	0.003	0.012	0.680	0.564	-1.074	1.091

*Average BAC includes only the twelve in-test readings

Due to the randomisation of the experimental condition, each BAC point was associated with a variety of subtests which were shown in “Methods” to be sufficiently randomised. The accuracy of average BAC readings was limited to two decimals points by the equipment utilised. The BAC readings followed a typical, expected pattern with positive skewness values deviating outside the common -1.000 to +1.000 range from point 2 and after point 10. The kurtosis statistics were outside of the usual range showing a leptokurtic curve at points one and two, with flattening to a platykurtic curve later in the assessment as BAC values declined and converged. The skewness and kurtosis values were consistent with the rapid peak and gradual drop expected of BAC levels. Figure 21 shows the BAC curve over the thirteen measurement points referenced to point 0 signifying the pre-alcohol consumption value.

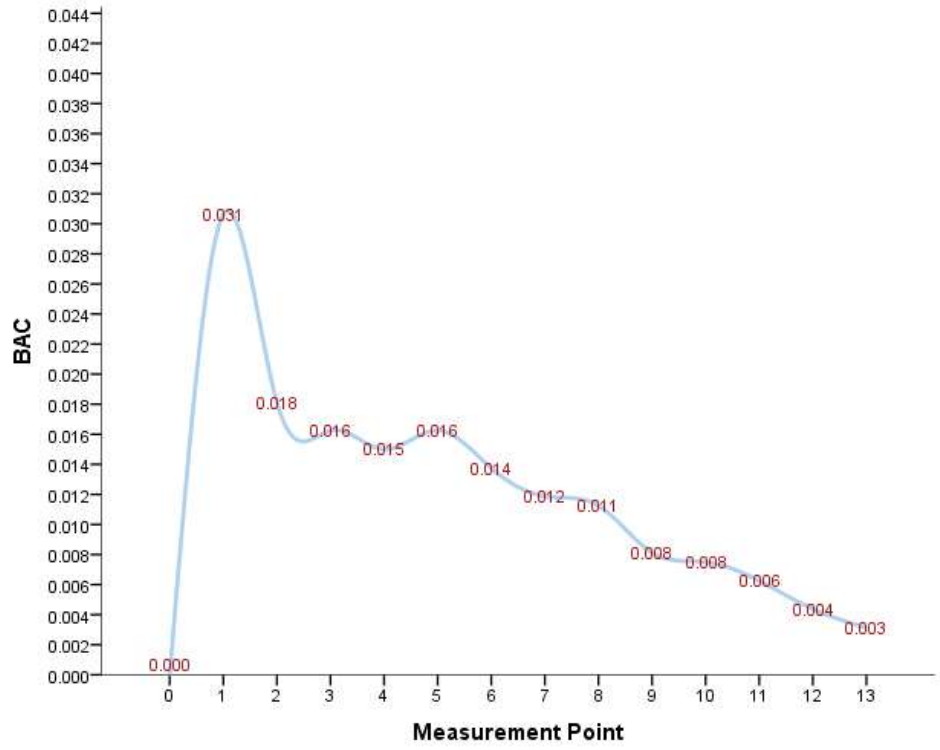


Figure 21. BAC Curve over the 13 reference points (n = 16)

Table 18 showed the assessments of normality for the BAC readings at each measurement point. Most of the individual point distributions statistically deviated from the hypothetical normal distribution, potentially due to the considerable number of tied ranks which can particularly impact the Shapiro-Wilk statistic which, despite being considered to have more power, is not necessarily suitable for data with multiple duplicate values as are present in the current research (Razali & Wah, Power comparisons of Shapiro-Wilk, Kolmogorov-Smirnov, Lilliefors and Anderson-Darling tests, 2011). In this case, the Kolmogorov-Smirnov statistics should be examined first. The BAC readings were also formally assessed for normality of distribution, the values for which are reported in Appendix B.

Since average BAC was utilised as the representative of all values, the achievement of normality was important in this case. This distribution was statistically significantly different from normal based on the Kolmogorov-Smirnov statistic (K-S = 0.241, p = .014) and Shapiro-Wilk test (S-W = 0.869, p = .026). Although this implies an absence of suitability for parametric analysis, the values were correct within the context of the variable's requirements for skewness (*skewness* = 0.680, SE_{Skewness} = 0.564). As a component of the experimental process, BAC value deviations from the norm behaved as expected. Therefore, these values were considered suitable for the analyses. Two psychometric assessments were used in the present research,

namely, the Raven's Progressive Matrices (Standard Form), as a control assessment of non-verbal intelligence, and the repeated measures of the Automated Working Memory Assessment (AWMA) subtests as the experimental assessment.

Raven's Progressive Matrices (Standard Form)

The sample's mean raw score on the RPM was 48.19 points out of 60 (*SD* = 5.935, *SE* = 1.484) with a minimum score of 39 and a maximum score of 58. The standard deviation values indicated a suitable level of variance with normal values of *skewness* = 0.026 (*SE* = .564) and *kurtosis* = -0.906 (*SE* = 1.091). Further tests of normality produced a Kolmogorov-Smirnov value of 0.104 (*p* = .200), and a Shapiro-Wilk value of 0.957 (*p* = .600), indicating a sufficiently normal distribution of data for the sample. Therefore, this data met the assumption of normality suggested for further inferential analysis. Figure 22 illustrates the distribution of RPM scores for this sample.

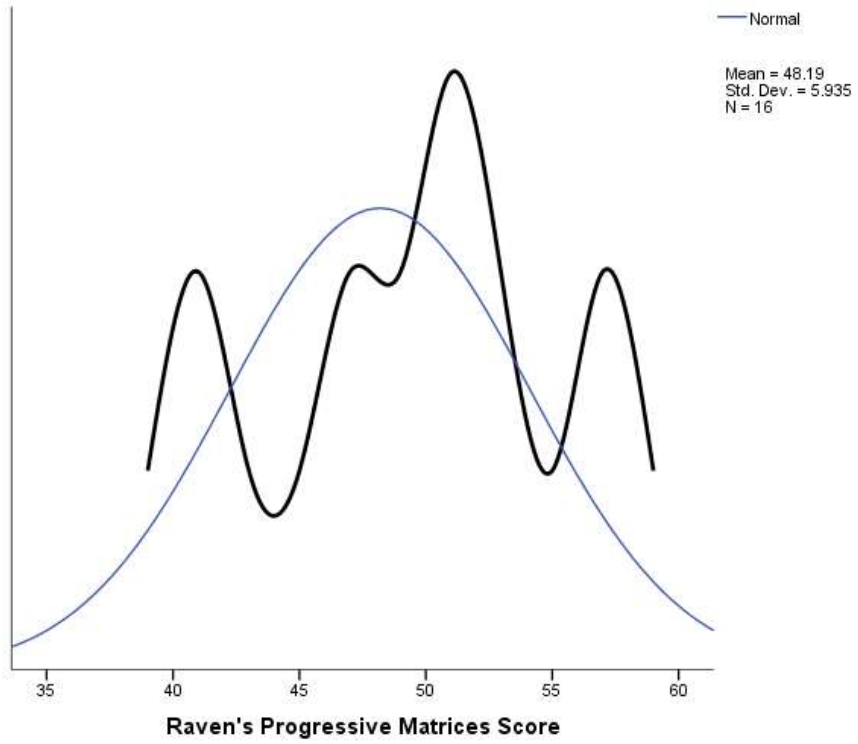


Figure 22. Raven's Progressive Matrices (Standard Form) score distribution (*n* = 16)

Figure 22 shows the slightly platykurtic distribution of the Raven's Progressive Matrices scores. The shape produced is partially the result of low frequency bins, or quintile groups, creating a more flattened appearance.

Automated Working Memory Assessment

The sample's scores on the baseline and experimental assessments of the AWMA were examined individually for each of the twelve subtests along with the relevant processing scores. The descriptive statistics and distributions are presented in Table 19. No outliers were identified as likely to impact the standard deviation values of the scores at either the baseline, or experimental, level.

Table 19

Descriptive Statistics and Distribution of the Twelve AWMA Subtests (n = 16)

	Baseline Assessment					*Experimental Assessment*				
	Max	*Min*	*M*	*SE*	*SD*	*Max*	*Min*	*M*	*SE*	*SD*
Digit Recall	133	71	90.69	3.86	15.44	133	69	90.75	4.12	16.46
Word Recall	116	66	83.30	3.73	14.92	120	66	80.94	3.95	15.80
Nonword Recall	122	82	103.72	2.19	8.77	122	77	102.60	3.39	13.56
Dot Matrix	113	68	89.13	3.49	13.97	130	63	92.13	4.32	17.26
Mazes Memory	126	74	99.50	3.54	14.15	126	66	93.00	4.14	16.56
Block Recall	118	60	82.44	3.46	13.84	106	65	82.56	3.20	12.79
Listening Recall	119	73	93.38	3.68	14.74	122	80	98.50	3.14	12.58
Counting Recall	119	76	96.50	2.74	10.97	122	80	103.13	3.19	12.76
Backwards Digit	130	47	86.19	4.89	19.56	132	67	93.00	4.60	18.42
Odd-One-Out	129	74	96.75	3.72	14.86	114	79	97.69	2.47	9.88
Mister X	123	81	97.75	3.51	14.05	134	68	101.31	4.52	18.07
Spatial Recall	127	75	99.25	4.26	17.04	125	79	98.31	4.05	16.21

In the baseline assessment, the average dispersion statistics over the full assessment (*Max* = 122.82, *Min* = 72.76, *M* = 94.09, *SE* = 3.57, *SD* 14.30) were like the standardised percentile score distribution values (*M* = 100, *SD* = 15). The standard errors of measurement were low and only the mean value for Word Recall (*M* = 83.30) was outside the -1 *SD* to +1 *SD* bracket when compared to the percentile means and standard deviations reported by Alloway (2007). Most standard deviations reported for this sample were within three points of the reported percentile standard deviation value (*SD* = 15.00), excepting Nonword Recall (*SD* = 8.77) and Counting Recall (*SD* = 10.97).

Examination of the experimental assessment values revealed similar standard average values (*Max* = 123.65, *Min* = 73.76, *M* = 95.83, *SE* = 3.65, *SD* = 14.60). The average of the standard deviations for the experimental assessment were also similar to those obtained after standardisation of the original instrument, with only the Odd-One-Out subtest (*SD* = 9.88) falling more than three points away from the standardised standard deviation of 15 points. The

statistics for both sessions of measurement suggest that the AWMA subtest dispersions were similar to those reported by Alloway (2007) during the standardisation process. Tests of normality were also calculated for the sample in the present research and are shown in Table 20.

Table 20

Skewness and Kurtosis of the AWMA Baseline and Experimental scores (n = 16)

	Skewness		*Kurtosis*			*Skewness*		*Kurtosis*	
	Statistic	*SE*	*Statistic*	*SE*		*Statistic*	*SE*	*Statistic*	*SE*
Digit Recall	1.640	0.564	2.996	1.091	Experimental Digit Recall	0.999	0.564	1.674	1.091
Word Recall	0.593	0.564	-0.377	1.091	Experimental Word Recall	1.245	0.564	1.038	1.091
Nonword Recall	-0.417	0.564	2.222	1.091	Experimental Nonword Recall	-0.591	0.564	-0.247	1.091
Dot Matrix	0.463	0.564	-0.950	1.091	Experimental Dot Matrix	0.290	0.564	0.091	1.091
Mazes Memory	0.409	0.564	0.251	1.091	Experimental Mazes Memory	0.422	0.564	0.039	1.091
Block Recall	0.909	0.564	1.754	1.091	Experimental Block Recall	0.197	0.564	-1.228	1.091
Listening Recall	0.298	0.564	-1.163	1.091	Experimental Listening Recall	0.406	0.564	-0.860	1.091
Counting Recall	0.463	0.564	0.545	1.091	Experimental Counting Recall	0.016	0.564	-0.929	1.091
Backwards Digit	0.596	0.564	1.669	1.091	Experimental Backwards Digit	0.868	0.564	0.172	1.091
Odd-One-Out	0.239	0.564	0.030	1.091	Experimental Odd-One-Out	0.171	0.564	-0.588	1.091
Mister X	0.664	0.564	-0.789	1.091	Experimental Mister X	0.076	0.564	-0.354	1.091
Spatial Recall	0.163	0.564	-1.442	1.091	Experimental Spatial Recall	0.671	0.564	-0.864	1.091

Most of the baseline subtest values of skewness were positive and only Digit Recall was outside of the -1 to +1 bracket (*skewness* = 1.640, SE_{Skewness} = 0.564). The exception is Nonword Recall (*skewness* = -0.417, SE_{Skewness} = 0.564) where slight negative skew was present, falling within the commonly accepted normality bracket. Standard errors of skewness were small overall ($SE_{Skewness}$ = 0.564), indicating quite small deviation around the calculated values to extrapolate to the population.

Several subtest values fell outside of the commonly accepted ranges for kurtosis. Digit Recall (*kurtosis* = 2.996, SE_{Kurtosis} = 1.091), Nonword Recall (*kurtosis* = 2.222, SE_{Kurtosis} = 1.091) and Block Recall (*kurtosis* = 1.754, SE_{Kurtosis} = 1.091). These three subtests showed a leptokurtic, or clustered, distribution outside the usual reference points. The other subtests were leptokurtic, but less dramatic in their deviation from the usual range reference. Some statistics

of kurtosis were negative, or platykurtic, and outside of the normal range. These were those for Listening Recall (*kurtosis* = -1.163, SE_{Kurtosis} = 1.019) and Spatial Recall (*kurtosis* = -1.442, SE_{Kurtosis} = 1.091). No pattern in clustering around the mean or wide spread was identified in based on the values of skewness or kurtosis for the baseline data.

Values of skewness and kurtosis for the experimental assessment data points were also examined. Slight positive skew (clustering to the left of the *x* axis values) was evident for Word Recall, which presented with a skewness value of 1.245 (SE_{Skewness} = 0.564), despite similar descriptive statistics to that of the baseline assessment. Most values for kurtosis were within, or very close to, normal bounds. Subtests such as Digit Recall (*kurtosis* = 1.674, SE_{Kurtosis} = 1.091) and Word Recall (*kurtosis* = 1.038, SE_{Kurtosis} = 1.091) were slightly elevated in the leptokurtic direction, particularly if the standard errors of $SE_{kurtosis}$ = 1.091 are accounted for. Conversely, the Block Recall distribution was platykurtic and outside the normally accepted range (*kurtosis* = -1.128, SE_{Kurtosis} = 1.091). The variations noted for the experimental assessment values were expected given the introduction of alcohol. Formal tests of normality for the AWMA baseline, and experimental, measurements are presented in Table 21.

Most of the subtests met the assumption of normality based on the Kolmogorov-Smirnov and Shapiro-Wilk statistics probability values (α = .05) (Table 21). A few of the subtests did deviate statistically significantly from the normal distribution. These were the baseline Digit Recall subtest (*K-S* = 0.230, *p* = .023), and Backwards Digit subtest (*K-S* = 0.239, *p* = .015) as well as the experimental assessments of Word Recall (*K-S* = 0.248, *p* = .009), the Odd-one-out (*K-S* = 0.215, *p* = .046) and Spatial Recall (*K-S* = 0.220, *p* = .038). Chapter 5 (“Methods”) considered the hypothesised internal structure of the AWMA. The internal correlation coefficients on the baseline and experimental levels for the present sample can be viewed in Appendix C.

Table 21

Kolmogorov-Smirnov and Shapiro-Wilk's Tests of Normality for the AWMA (n = 16)

	Kolmogorov-Smirnov		*Shapiro-Wilk*			*Kolmogorov-Smirnov*		*Shapiro-Wilk*	
	Statistic	*p*	Statistic	*p*		Statistic	*p*	Statistic	*p*
Digit Recall	0.230	.023*	0.831	.007**	Experimental Digit Recall	0.165	.200	0.925	.201
Word Recall	0.193	.116	0.916	.144	Experimental Word Recall	0.248	.009**	0.853	.015*
Nonword Recall	0.207	.066	0.927	.216	Experimental Nonword Recall	0.171	.200	0.933	.273
Dot Matrix	0.157	.200	0.932	.267	Experimental Dot Matrix	0.160	.200	0.951	.513
Mazes Memory	0.167	.200	0.952	.519	Experimental Mazes Memory	0.131	.200	0.959	.635
Block Recall	0.130	.200	0.941	.365	Experimental Block Recall	0.207	.064	0.923	.188
Listening Recall	0.167	.200	0.934	.278	Experimental Listening Recall	0.195	.106	0.920	.169
Counting Recall	0.160	.200	0.958	.634	Experimental Counting Recall	0.189	.129	0.933	.269
Backwards Digit	0.239	.015*	0.912	.124	Experimental Backwards Digit	0.169	.200	0.918	.159
Odd-One-Out	0.113	.200	0.962	.696	Experimental Odd-One-Out	0.215	.046*	0.935	.296
Mister X	0.174	.200	0.898	.075	Experimental Mister X	0.143	.200	.950	.486
Spatial Recall	0.157	.200	0.924	.194	Experimental Spatial Recall	0.220	.038*	0.871	.028*

*Significant at the 5% level

**Significant at the 1% level

Lastly, the Brief Biphasic Alcohol Effects Scale (B-BAES) was examined as an additional measurement designed to detect subjective intoxication which may have influenced performance on the experimental assessment if found to be significant.

Brief Biphasic Alcohol Effects Scale

The Brief Biphasic Alcohol Effects Scale (B-BAES), consisting of its six measurement points, was used for measurements at each of the twelve subtest data points with the addition of pre-alcohol and post-test. Analysis of the B-BAES use for these purposes rested on the hypothesised factor structure and strength (see "Instruments" in Chapter 5) as the measure was never intended to produce a normal distribution of scores due to the objective of measurement and the ordinal nature of measurement. The lack of expected normality is due to the functioning

of the instrument whereby scores should be truncated (if the instrument is functioning correctly) depending on the time of measurement. Therefore, tests of skewness and kurtosis provide a good indication of the adherence to the expectation of positive or negative skew throughout the assessment. Ratings measuring the stimulation component, "Energised", "Excited" and "Up", should be negatively skewed towards the beginning of the assessment and positively skewed towards the end. The sedation component, consisting of the items "Sedated", "Slow Thoughts" and "Sluggish", should present positive skew towards the beginning of the assessments and negative skew towards the end. Table 22 shows the descriptive statistics for the B-BAES values.

Table 22

Means and Skewness Statistics of the B-BAES items (n = 16)

	Energised		*Excited*		*Sedated*		*Slow Thoughts*		*Sluggish*		*Up*	
Point	*M*	*Skew*	*M*	*Skew*	*M*	*Skew*	*M*	*Skew*	*M*	*Skew*	*M*	*Skew*
0	6.438	-0.364	6.688	-0.317	3.500	0.478	3.063	0.884	4.313	-0.001	6.313	-0.324
1	6.500	-0.364	7.125	-0.184	3.375	0.264	3.813	0.636	4.125	0.437	6.000	-0.227
2	7.063	-0.557	7.063	-0.031	4.125	-0.177	4.625	0.169	4.188	0.356	6.563	-0.076
3	6.188	-0.794	6.563	-0.909	4.188	-0.044	4.813	0.677	3.750	0.088	6.313	0.063
4	6.375	-1.010	6.688	-0.897	4.063	-0.023	4.625	0.180	3.875	0.339	6.500	-0.244
5	6.313	-1.071	6.563	-0.383	4.313	0.059	4.625	0.229	4.313	0.064	5.750	-0.194
6	6.500	-0.413	6.500	-0.343	4.188	-0.107	4.813	0.176	3.688	0.216	6.063	0.271
7	6.563	-1.505	6.688	-0.412	3.625	-0.116	4.625	0.254	4.000	0.000	6.000	-0.453
8	5.813	-0.381	6.438	-0.360	3.875	-0.245	4.688	0.867	4.000	-0.091	5.813	-0.023
9	5.938	0.028	6.500	-0.322	3.813	0.186	4.625	-0.457	4.125	0.343	5.875	0.138
10	5.813	-0.098	6.500	-0.080	4.125	0.311	5.000	-0.036	4.125	0.245	5.625	-0.125
11	5.625	-0.717	6.250	-0.337	3.813	0.475	5.250	-0.123	4.313	0.012	5.563	0.165
12	6.313	-1.068	6.438	-0.597	4.000	0.345	4.938	0.703	4.438	-0.024	6.063	-0.772
13	5.750	-0.362	6.375	-0.421	3.625	0.826	4.875	0.520	4.188	0.172	5.563	-0.216

Data representing the mean of each item across the thirteen data points does not demonstrate a clear pattern. In general, the ratings for "Energised", "Excited" and "Up", the stimulant effects items, were higher and tending towards equality towards the end of the assessment. Based on this trend, for this sample, alcohol seemed to create a more stimulating than sedating effect. Because the differences and relationships are subtle, the assessment can be further described through correlational and variance studies. Table 23 shows the correlation matrix for the mean rating on each item over the thirteen reference points.

Table 23

Correlation Matrix of the B-BAES Mean Ratings over the Thirteen Reference Points (n = 16)

	Energised	Excited	Sedated	Slow Thoughts	Sluggish	Up
Energised	1					
Excited	.796**	1				
Sedated	.087	-.225	1			
Slow	-.410	-.559*	.565*	1		
Sluggish	-.122	-.068	-.270	-.148	1	
Up	.787**	.619*	.149	-.401	-.307	1

*Significant at the 5% level

**Significant at the 1% level

Correlation coefficients confirm the general structure of the instrument. Strong coefficients (Pearson's *r*) were calculated between the three items on the stimulant scale, all of which were statistically significant at the 5% or 1% level. The sedative scale items were less strongly related, showing more modest and variable coefficients. Only the relationship between "Slow" and "Sedated" was statistically significant ($r = .565$, $p < .05$) for this group of items. The terms "Sluggish" did not seem to elicit clear relationships with any of the terms, producing variable and close to zero coefficients. The data point values were grouped as first half and second half, excluding the pre- and post-test points, for comparative purposes. Independent samples *t*-tests revealed statistically significant differences bolstered bootstrapped results to $B = 1000$ iterations. Table 24 shows statistical differences between the first and second halves of the experimental assessment on the B-BAES assuming equal variance.

Table 24

Independent Samples t-tests Comparing the First and Second Halves of the B-BAES (n = 16)

	Levene's		*t-test*			*First Half to Second half*		*B = 1000*		
	F	*Sig.*	*t*	*df*	*p*	*M Diff*	*SE Diff*	*Bias*	*SE*	*p*
Energised	0.610	.453	2.510	10	.031*	0.479	0.191	-0.004	0.185	.029*
Excited	5.141	.047*	2.237	10	.049*	0.281	0.126	-0.002	0.124	.103
Sedated	0.873	.372	1.079	10	.306	0.167	0.155	0.004	0.151	.377
Slow Thoughts	0.111	.745	-1.641	10	.132	-0.302	0.184	0.008	0.176	a
Sluggish	2.562	.141	-1.402	10	.191	-0.177	0.126	0.001	0.122	.189
Up	2.319	.159	2.465	10	.033*	0.375	0.152	0.001	0.144	.048*

a Value could not be computed after 1000 sample splits

*Significant at the 5% level

As the comparison of the first and second halves of the assessment illustrates, the items measuring the stimulating effect of alcohol seemed to be subject to more influence of varying BAC readings throughout the course of the assessment. Since the dosage of alcohol was

extremely low, interpretations of this information should be made with caution. To appropriately use the B-BAES values for analysis, based on the available data, a specific scale was created in accordance with the instrument's association with breath alcohol concentration levels discussed later in this section.

Potential Covariates of Measurement

This section considers the interrelationships of the variables for identifying, or justifying, the inclusion of covariates in the inferential analyses. Several potential covariates were identified and are discussed in the coming sections. The RPM was identified as theoretically important for the visuo-spatially based subtests and examined briefly beforehand with regards to all subtests given the potential for a general relationship between intelligence and memory. Breath alcohol concentration and the B-BAES were considered as covariates related to the administration of alcohol. For BAC, averages over the test sessions were deemed sufficient, particularly given the tapering towards zero after point four of the assessment process. The end of this section details the organisation of the B-BAES into a statistically useful scale for inclusion as a covariate. Test-retest delay was also considered as potentially important.

The Automated Working Memory Assessment's Relationship with the Raven's Progressive Matrices (Standard Form)

The "Methods" section (Chapter 5) discussed the two psychometric instruments used in the present research. The Raven's Progressive Matrices (Standard Form) (RPM) was utilised as a potential covariate for intelligence. Therefore, this assessment was conducted only during the baseline test session. As discussed in the literature review (see Chapter 3), intelligence and working memory are, potentially, interrelated constructs (e.g. Ackerman et al., 2005; Colom et al., 2004). Therefore, the mediating or moderating effects of the RPM interrelationships with the AWMA scores need to be considered in the context of any differences seen following the administration of alcohol.

Strong correlation coefficients were only observed between the visuo-spatial subtests of the AWMA and the RPM values ($p < .05$). The verbally based subtests were not closely associated with the visually-based RPM instrument and, therefore, the RPM was not included as a covariate for those analyses. The correlation coefficients are presented in Table 25 which also shows similar coefficients of Pearson's r and Spearman's rho, as well as low levels of bias based on bias corrected accelerated (BCa) ($B = 1000$) bootstrapping protocol.

Table 25

Pearson's r and Spearman's rho Correlation Coefficients Between the RPM Scores and the Baseline AWMA Subtest Scores (n = 16)

	r	ρ	BCa Bias (*B* = 1000)
Digit Recall	-.023	.016	-.013
Word Recall	.494	.557*	.010
Nonword Recall	.196	.101	-.033
Dot Matrix	.516*	.558*	-.001
Mazes Memory	.590*	.606*	-.019
Block Recall	.582*	.549*	-.017
Listening Recall	.483	.438	-.027
Counting Recall	.274	.251	-.012
Backwards Digit	.123	-.016	-.038
Odd-One-Out	.670**	.763**	.003
Mister X	.616*	.556*	-.020
Spatial Recall	.614*	.639**	-.010

* Significant at the 5% level

** Significant at the 1% level

Several statistically significant correlations between the baseline AWMA scores and RPM raw scores were present. In-text, the Pearson's *r* values are reported whilst the Spearman's rho values were listed in Table 25 for comparative purposes. The correlations were not statistically significant between the RPM and the Digit Recall subtest (r = -.023, p > .05), Word Recall subtest (r = .494, p > .05) and Nonword Recall subtest (r = .196, p > .05). On the other hand, statistically significant correlations to the RPM were calculated for the Dot Matrix (r = .516, p < .05), Mazes Memory (r = .590, p < .05) and Block Recall (r = .582, p < .05) subtests. Based on the theoretical considerations, and correlation coefficients, the RPM was included as a covariate for the analyses involving Visuo-spatial Short-term Memory subtests.

None of the Verbal Short-term Memory AWMA scores were statistically significantly correlated with the RPM (p > .05). A moderate correlation coefficient was present between the Listening Recall subtest score and the RPM (r = .483, p > .05), whilst weak associations were present for Listening Recall Processing (r = .284, p > .05), Counting Recall (r = .274, p > .05), Counting Recall Processing (r = .246, p > .05) and Backwards Digit (r = .123, p > .05). The RPM was statistically significantly associated with the Visuo-spatial Working Memory subtests, namely, the Odd-one-out subtest (r = .670, p < .01), Mister X subtest (r = .616, p < .05) and the Spatial Recall subtest (r = .614, p < .05). From these results it is apparent that, certainly for the visuo-spatially based subtests, it is worthwhile to include the RPM as a source of variance in the inferential analyses. The positive values of the correlation coefficients

suggested that better performance on the RPM is, as expected, associated with better performance on the AWMA subtests measuring visuo-spatial short-term, or working, memory.

The Brief Biphasic Alcohol Effects Scale Comparisons on Age and the Lifestyle Variables

The primary purpose of the B-BAES was the measurement of the subjective effects of intoxication based on levels of stimulation versus sedation. These are age, weekly drinking behaviour and binge drinking behaviour. Correlations between the B-BAES item scores throughout the experimental assessment were conducted based on both Pearson's *r* and Spearman's ρ. Initial examination of the correlations revealed several medium strength negative and positive correlation coefficients, some of which were statistically significant at both the 5% and 1% levels. Caution should be used in interpreting correlations involving the drinking patterns as an extremely limited range of scores was present. In these cases, Spearman's rho is perhaps more appropriate for interpretation due to the statistic's ability to separate tied ranks. Despite these limitations, examination of these coefficients was useful to understand the functioning of the B-BAES in relation to the demographic and lifestyle variables. The correlation coefficients are shown in Appendix D.

The Pearson's *r* and Spearman's rho correlation coefficients were similar in value across all variables indicating good applications of the statistics. Some statistically significant correlations were present ($p < .05$). See Appendix D for the full values. The trends demonstrate a tendency for younger participants to experience higher levels of subjective stimulation throughout the assessment. This association is explored further in later sections using age as a covariate. A few statistically significant correlation coefficients ($p < .05$) also suggested that those persons who consumed more alcohol units per week experienced a tendency towards higher levels of stimulation. The correlations between weekly alcohol consumption and the B-BAES were generally inconclusive. Lastly, a similar relationship was seen for the correlation between the B-BAES items and binge drinking episodes. Most of the statistically significant correlation coefficients occurred towards the beginning of the assessment. These associations were not sufficient to include binge drinking episodes and weekly consumption as covariates in the inferential analyses without first considering the association of these lifestyle variables with BAC levels.

Breath Alcohol Concentrations (BAC) Comparisons between the Demographic and Lifestyle Variables

Breath alcohol concentrations were correlated with variables identified in the literature as potentially influencing the metabolism of alcohol (see Chapter 4). These commonly identified variables were age, body mass index, exercise levels, weekly alcohol consumption and frequency of binge drinking episodes (Suter & Schutz, 2008). Each was briefly examined for association with BAC readings to determine whether, or not, extraneous variance should be accounted for in later analyses. This was considered in context of the findings regarding subjective intoxication. Table 26 presents the results.

Table 26

Correlations Between the BAC Points on the Demographic and Lifestyle Variables

	Age		*BMI*		*Exercise per week*		*Units per week*		*Binge Drinking Sessions*	
	r	*ρ*	*r*	*ρ*	*r*	*ρ*	*r*	*ρ*	*r*	*ρ*
Average BAC	-.581*	-.682**	-.408	-.289	.119	.138	.104	.180	.067	.097
BAC 1	-.258	-.287	-.407	-.364	-.077	-.009	.091	.217	-.206	-.008
BAC 2	-.346	-.426	-.308	-.204	.118	.154	-.048	.002	-.128	.060
BAC 3	-.461	-.480	-.245	-.092	.184	.172	.022	.062	.098	.170
BAC 4	-.552*	-.633**	-.374	-.275	.210	.251	.129	.207	.063	.116
BAC 5	-.648**	-.722**	-.418	-.326	.233	.236	.210	.285	.140	.151
BAC 6	-.660**	-.696**	-.460	-.340	.033	.070	.244	.266	.163	.166
BAC 7	-.587*	-.655**	-.424	-.374	.131	.125	.152	.275	.154	.193
BAC 8	-.622*	-.687**	-.416	-.370	.155	.155	.172	.292	.251	.252
BAC 9	-.638**	-.694**	-.372	-.314	.132	.186	.048	.142	.070	.074
BAC 10	-.565*	-.606*	-.315	-.244	.153	.214	.000	.069	.092	.120
BAC 11	-.544*	-.586*	-.293	-.247	.017	.161	-.035	.060	.051	.088
BAC 12	-.589*	-.591*	-.286	-.268	-.056	.038	.023	.113	.168	.196
BAC Post-test	-.557*	-.583*	-.255	-.164	-.095	-.043	-.028	.022	.122	.075

* Significant at the 5% level

** Significant at the 1% level

Participant ages were significantly correlated with BAC readings ($p < .05$) in most cases although most of the correlation coefficients were negative suggesting greater BAC values being present for younger ages. The values are summarised by the statistically significant negative relationship between average BAC and age of participant ($r = -.581$, $p = .018$). Therefore, it is likely that persons who are older exhibited lower BAC measurements throughout the assessment. Average BAC was used in the inferential analyses and this finding confirmed the necessity of including participant age as a covariate.

Body mass index was not significantly correlated ($p > .05$) with any of the BAC points although moderate negative correlation coefficients between $r = -.245$ and $r = -.460$ were

observed. The moderate negative relationship implies some tendency towards lower BAC measurements when BMI calculated values were higher. Unlike the values for participant age, the correlation coefficients for BMI were consistent throughout the BAC points. Spearman's rho correlation coefficients, calculated as an addition due to the limited range of measurement of the variables, between BAC values and the variables measuring amount of exercise per week, number of units consumed per week and binge drinking were weak ($\rho < .275$) and were not statistically significant ($p > .05$) in any of the cases. It was established that participant age was correlated with average BAC, as well as several points on the B-BAES measure. The relationship between subjective intoxication and average BAC was also important.

The Relationship Between BAC and The B-BAES

A general trend of stronger correlations between average BAC and early measurements of the "Stimulated" scale items was present. Correlation coefficients between average BAC and the "Sedated" scale items were generally weak with some tendency to negative correlation coefficients at the end points of the assessment. Since several correlation coefficients were of a moderate value, the two scales at each measurement point were also considered. The correlation matrix showing details of the relationship between each B-BAES item and each BAC measurement point is recorded in Appendix E. Table 27 shows the correlation coefficients between average BAC and the B-BAES summative scales.

As Table 27 shows, discrepancies are present between the Pearson's *r* and Spearman's rho statistics, particularly regarding levels of statistical significance. Given the number of likely tied ranks in values for both variables, due to the nature of measurement, Spearman's rho may be of more use. Average BAC was statistically significantly correlated with the measurements of stimulation on the scale at measurements points one ($\rho = .501$, $p = .048$), two ($\rho = .574$, $p = .020$), four ($\rho = .517$, $p = .040$) and five ($\rho = .535$, $p = .033$). Average BAC was statistically significantly correlated with the sedated items at measurement points four ($\rho = .517$, $p = .040$), eleven ($\rho = .511$, $p = .043$) and twelve ($\rho = .574$, $p = .020$). The findings suggest a division based on average BAC whereby higher early readings are associated with higher levels of early stimulation as well as higher levels of later sedation.

Table 27

Correlations Between Average BAC and the Stimulated and Sedated B-BAES Scales (n = 16)

	Average BAC			
	r	*p*	*ρ*	*p*
Pre-alcohol Stimulated Scale	.414	.111	.460	.073
Pre-alcohol Sedated Scale	.340	.198	.441	.087
Stimulated Scale Point 1	.428	.098	.501*	.048
Sedated Scale Point 1	.377	.150	.446	.084
Stimulated Scale Point 2	.498*	.049	.574*	.020
Sedated Scale Point 2	.306	.249	.396	.128
Sedated Scale Point 3	.462	.072	.434	.093
Stimulated Scale Point 4	.161	.552	.274	.305
Sedated Scale Point 4	.438	.089	.517*	.040
Stimulated Scale Point 5	.492	.053	.535*	.033
Sedated Scale Point 5	.056	.837	.213	.428
Stimulated Scale Point 6	.264	.322	.338	.201
Sedated Scale Point 6	.096	.722	.195	.469
Stimulated Scale Point 7	.400	.125	.410	.114
Sedated Scale Point 7	.190	.481	.250	.351
Stimulated Scale Point 8	.264	.323	.313	.238
Sedated Scale Point 8	.149	.581	.236	.380
Stimulated Scale Point 9	.163	.547	.218	.417
Sedated Scale Point 9	.307	.247	.437	.091
Stimulated Scale Point 10	.286	.284	.197	.465
Sedated Scale Point 10	.208	.440	.437	.090
Stimulated Scale Point 11	.101	.710	.031	.911
Sedated Scale Point 11	.384	.141	.511*	.043
Stimulated Scale Point 12	.177	.512	.197	.465
Sedated Scale Point 12	.414	.111	.574*	.020
Stimulated Scale Post-test	.247	.357	.192	.477
Sedated Scale Post-test	.275	.302	.541*	.030

* Significant at the 5% level

Based on the available coefficients, and earlier identification of critical measurement points, two scales were considered further, namely, the “Stimulated” scale consisting of the average of “Stimulated” over points one through four, and the “Sedated” scale, consisting of the average of the “Sedated” points eight through twelve. Table 28 shows the correlation coefficients between these two scales and average BAC.

Table 28

Correlation Coefficients Between the Derived "Stimulated" scale, "Sedated" scale and Average BAC (n = 16)

		Average BAC		"Stimulated"		"Sedated"	
		Coefficient	Sig	Coefficient	Sig	Coefficient	Sig
Average BAC	*r*			.497	.050	.314	.236
"Stimulated": Points 1-4	*r*	.497	.050			.198	.461
"Sedated": Points 8-12	*r*	.314	.236	.198	.461		
Average BAC	ρ			.550*	.027	.486	.056
"Stimulated"	ρ	.550*	.027			.122	.652
"Sedated"	ρ	.486	.056	.122	.652		

* Significant at the 5% level

Measurements of early "Stimulated" feelings were positively correlated with average BAC (r = .497, p = .050; ρ = .550, p = .027) and less strongly statistically associated with later feelings of sedation (r = .314, p = .236; ρ = .486, p = .056). Feelings of being "Sedated" towards the end of the assessment were positively correlated with average BAC values, but as not strongly so (r = .314, p = .236; ρ = .486, p = .056). Figure 23 visually explains the generally stronger congruence with the "Stimulated" items at the beginning of the assessment, in comparison to the average agreement with the "Sedated" end of assessment scale.

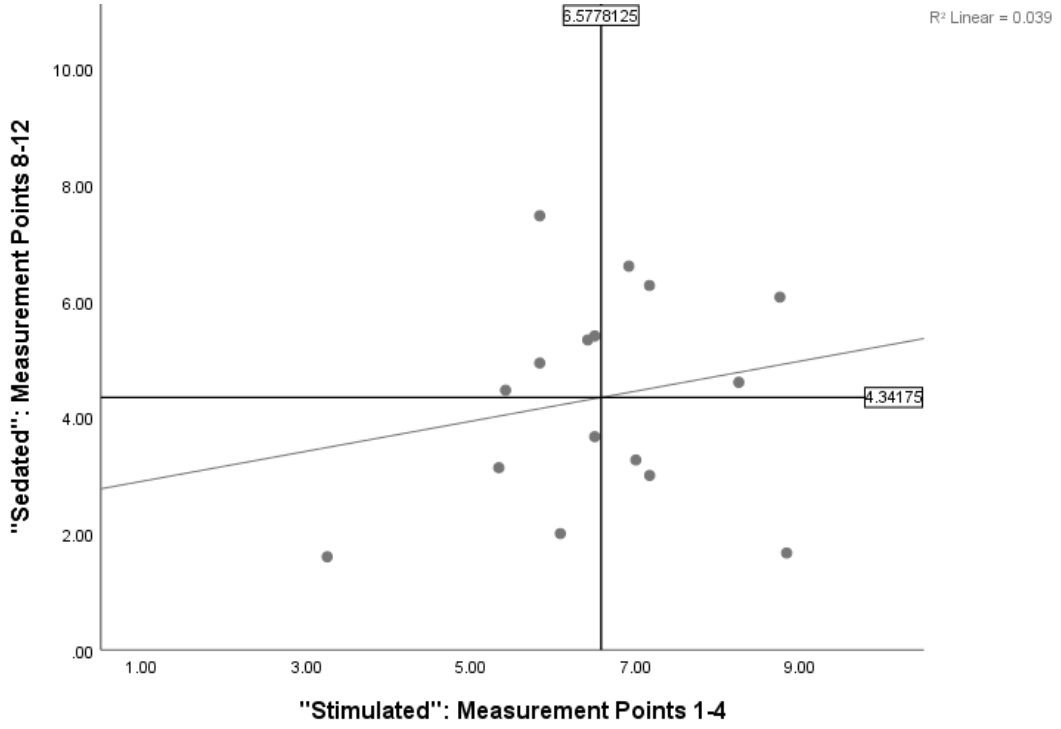


Figure 23. Correlational Structure Between the "Stimulated" and "Sedated" Derived Scales (n = 16)

Resultantly, feelings of "Sedation" towards the end of the assessment appeared to be centrally distributed within the ten-point scale (M = 4.342), whilst stronger congruence with "Stimulated" feelings was seen during the early portions of the assessment (M = 6.579). Given the strength of correlation coefficients, timing of points of measurement for each of the two scales, and positioning on the ten-point scale, the measurement points one through four "Stimulated" scale was considered the most likely to have an impact on variance seen between the means on each subtest. This scale, "Stimulated", was utilised as a covariate representative of the B-BAES relationship with both average BAC and participant age. The prior sections identified covariates for further usage. Participant age was established as being associated with both average BAC and subjective stimulation early in the assessment. These three covariates were included for all analyses. The RPM was established as being associated with the visuo-spatially based subtests and, therefore, included in those analyses. Test-retest delay was erratically associated but statistics were sufficient to include this theoretically important variable in the analyses. The next section discusses the inferential statistics. Internal correlation structures depicting alterations in instrument behaviour and repeated measures models are presented and reported.

Inferential Analyses

The inferential analyses are centred around the primary research question, namely, whether the consumption of a small amount of alcohol produces a change in performance on the Automated Working Memory Assessment in comparison to initial baseline readings. Based on the preliminary analyses, several covariates were identified as important in considering the research questions. Participant age, the B-BAES "Stimulated" derived scale and test-retest delay, explained further in this section, were included for all subtests. The RPM was considered as a covariate for the short-term, and working, memory assessments in the Visuo-spatial domain. Comprehensive consideration of such covariates has not been included in other studies exploring this type of research question. Prior to formal repeated measures comparisons, the baseline and experimental AWMA measures underwent separate preliminary analyses to determine the differences over the two assessment sessions.

Preliminary Comparisons of the Repeated Measures

Descriptive differences between the baseline and experimental AWMA scores. The majority of the AWMA subtest scores increased under the experimental condition although the short-term memory subtests were quite stable. This was particularly consistent for the Verbal

Working Memory scores whilst the differences were more variable for the short-term memory subtests resulting in composite score differences closer to zero. Negative values of mean difference indicate an improvement in performance whilst positive values indicate a decrease in performance based on the subtraction of the experimental values from the baseline values to calculate the difference, labelled as "baseline – experimental". Table 29 shows the baseline, experimental and difference descriptive statistics on the AWMA subtests.

Table 29 shows the difference values based on the experimental value being subtracted from the baseline value. The Mazes Memory subtest was notable as it showed a dramatic decline in performance during the experimental condition ($M_{\text{Difference}}$ = 6.50). The largest difference values were apparent for the working memory measurements, usually in favour of improvements in performance under the experimental condition. The statistical significance of the score changes is reported later in these sections.

Table 29

Baseline, Experimental and Baseline Repeated Measures (Baseline – Experimental) Descriptive Statistics for the AWMA (n = 16)

	Baseline				*Experimental*				*Repeated-measures Difference*			
	M	*SD*	*Max*	*Min*	*M*	*SD*	*Max*	*Min*	*M*	*SD*	*Max*	*Min*
Digit Recall	91.00	15.00	133.00	71.00	91.00	16.00	133.00	69.00	-0.06	8.99	19.00	-14.00
Word Recall	83.30	14.90	116.00	66.00	81.00	16.00	120.00	66.00	2.36	8.30	18.90	-11.00
Nonword Recall	103.70	8.80	122.00	82.00	102.60	13.60	122.00	77.00	1.12	12.93	32.00	-18.10
Dot Matrix	89.00	14.00	113.00	68.00	92.00	17.00	130.00	63.00	-3.00	11.52	17.00	-25.00
Mazes Memory	100.00	14.00	126.00	74.00	93.00	17.00	126.00	66.00	6.50	16.39	32.00	-28.00
Block Recall	82.00	14.00	118.00	60.00	83.00	13.00	106.00	65.00	-0.13	9.08	20.00	-12.00
Listening Recall	93.00	15.00	119.00	73.00	99.00	13.00	122.00	80.00	-5.13	10.75	14.00	-21.00
Counting Recall	97.00	11.00	119.00	76.00	103.00	13.00	122.00	80.00	-6.63	11.40	13.00	-23.00
Backwards Digit	86.00	20.00	130.00	47.00	93.00	18.00	132.00	67.00	-6.81	13.71	18.00	-39.00
Odd-One-Out	97.00	15.00	129.00	74.00	98.00	10.00	114.00	79.00	-0.94	9.91	18.00	-18.00
Mister X	98.00	14.00	123.00	81.00	101.00	18.00	134.00	68.00	-3.56	11.97	13.00	-24.00
Spatial Recall	99.00	17.00	127.00	75.00	98.00	16.00	125.00	79.00	0.94	7.38	16.00	-11.00

Preliminary repeated measures analyses of variance. General linear models were created for each of the subtest score differences. Due to the small sample size, confirmatory matched pairs *t*-tests were also conducted with bias corrected accelerated (BCa) bootstrapping (B = 1000) yielding the same statistics along with measures of bias. The bias values were minimal, indicating the suitability of the sample. The correlation coefficients representing the internal baseline-experimental structure of the AWMA are presented in Appendix F whilst the

bootstrapped *t*-test findings can be viewed in Appendix G. For the repeated measures analysis of variance, the sphericity assumed statistics are reported as the assumption of sphericity is automatically met due to the presence of only one nominal grouping. In addition to the *F* statistics and their significance, the effect sizes, reflected by partial eta-squared, and the observed power are reported. Later, identified covariates are also considered and the model statistics are compared for changes.

Table 30 shows the statistics for the repeated measures analysis of variance for the AWMA subtests. Effect sizes and reported power provide additional interpretive information in conjunction to the *F* statistics and probability values. Whilst the paired t-tests provided additional confirmatory information via the bootstrapping protocol, the analysis of variance findings also provide the effect size given the likelihood that the results are reliable under these circumstances.

Table 30:

Repeated Measures Analysis of Variance of the AWMA Subtests (n = 16)

	Model			*Error*			*Model Statistics*			
	*SS**	*df*	*Mean Square*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*
Digit Recall	0.031	1	0.031	605.469	15	40.365	0.001	.978	.000	.050
Word Recall	44.651	1	44.651	516.159	15	34.411	1.298	.273	.080	.187
Nonword Recall	10.013	1	10.013	1254.522	15	83.635	0.120	.734	.008	.062
Dot Matrix	72.000	1	72.000	995.000	15	66.333	1.085	.314	.067	.164
Mazes Memory	338.000	1	338.000	2014.000	15	134.267	2.517	.133	.144	.318
Block Recall	0.125	1	0.125	617.875	15	41.192	0.003	.957	.000	.050
Listening Recall	210.125	1	210.125	866.875	15	57.792	3.636	.076	.195	.431
Counting Recall	351.125	1	351.125	974.875	15	64.992	5.403	.035	.265	.585
Backwards Digit	371.281	1	371.281	1410.219	15	94.015	3.949	.065	.208	.460
Odd-One-Out	7.031	1	7.031	736.469	15	49.098	0.143	.710	.009	.065
Mister X	101.531	1	101.531	1073.969	15	71.598	1.418	.252	.086	.200
Spatial Recall	7.031	1	7.031	408.469	15	27.231	0.258	.619	.017	.258

*Type III Sum of Squares

For the Verbal Short-term Memory subtests, the scores on the Digit Recall subtest in the baseline condition were fractionally higher than those in the experimental condition ($M_{\text{Difference}}$ = -0.063, $SD_{\text{Difference}}$ = 8.985, SE_{Mean} = 2.246) but the differences were not statistically significant and the effect size was small ($F(1,15) = 0.001$, $p = .978$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). The mean difference scores on Word Recall subtest ($M_{\text{Difference}}$ = 2.363, $SD_{\text{Difference}}$ = 8.296, SE_{Mean} = 2.074) were larger than that for the Digit Recall subtest and represented a deterioration in performance under the experimental condition, but the effect size was also small and the differences were not statistically significant ($F(1,15) = 1.298$, $p = .273$, $\eta^2_{Partial} = .080$, $1 - \beta = .187$). The Nonword Recall subtest's mean difference ($M_{\text{Difference}}$ = 1.119, $SD_{\text{Difference}}$ = 12.933, SE_{Mean} = 3.233) was less substantial than that of the Word Recall score and reflected poorer performance in the experimental condition without a statistically

significant difference between the means (F(1,15) = 0.120, p = .734, $\eta^2_{Partial}$ = .008, 1 – β = .062). The lack of statistical significance, coupled with small effect sizes, suggested an absence of change in performance over the two conditions.

The Verbal Working Memory subtests had statistically significant differences (p < .05) in two cases and differences were approaching statistical significance (p < .08) in two cases. The improvements in performance in the experimental assessment for the repeated measures differences for the Listening Recall subtest scores ($M_{\text{Difference}}$ = -5.125 $SD_{\text{Difference}}$ = 10.751, SE_{Mean} = 2.688) approached statistical significance with a substantial effect size (F(1,15) = 3.535, p = .076, $\eta^2_{Partial}$ = .195, 1 – β = .431). The repeated measures mean differences for the Counting Recall subtest score ($M_{\text{Difference}}$ = -6.625, $SD_{\text{Difference}}$ = 11.355, SE_{Mean} = 2.850) show the improvement in performance during the experimental condition. Significant differences, with very large effect sizes, were observed between the baseline and experimental measures of Counting Recall (F(1,15) = 5.403, p = .035, $\eta^2_{Partial}$ = .265, 1 – β = .585). The mean experimental session value for the Backwards Digit subtest of verbal working memory was also larger than the baseline value ($M_{\text{Difference}}$ = -6.813, $SD_{\text{Difference}}$ = 13.712, SE_{Mean} = 3.428) but only approached statistical significance although the effect size was very large (F(1,15) = 3.949, p = .065, $\eta^2_{Partial}$ = .208, 1 – β = .460). The Visuo-spatial Short-term Memory subtest scores were inconsistent in the absolute value, and direction, of the mean differences but did have smaller probability values in most cases.

For the Visuo-spatial Short-term Memory subtests, the repeated measures differences for the Dot Matrix subtest showed some improvement in mean performance during the experimental condition ($M_{\text{Difference}}$ = -3.000, $SD_{\text{Difference}}$ = 11.518, SE_{Mean} = 2.880) but were not statistically significant with a small effect size (F(1,15) = 1.085, p = .314, $\eta^2_{Partial}$ = .067, 1 – β = .164). On the other hand, the Mazes Memory subtest effect size was large, without achieving statistical significance (F(1,15) = 2.517, p = .133, $\eta^2_{Partial}$ = .144, 1 – β = .318). The Mazes Memory subtest values represented a substantial deterioration in performance during the experimental assessment session ($M_{\text{Difference}}$ = 6.500, $SD_{\text{Difference}}$ = 16.387, SE_{Mean} = 4.097). Statistical differences between the two assessment sessions on the Block Recall subtest were negligible ($M_{\text{Difference}}$ = -0.125, $SD_{\text{Difference}}$ = 9.077, SE_{Mean} = 2.269) and small statistics and effect size were calculated (F(1,15) = 0.003, p = .957, $\eta^2_{Partial}$ = .000, 1 – β = .050). The Visuo-spatial Working Memory subtests also had variable statistics of difference.

Of the Visuo-spatial Working Memory subtests, mean values representing performance in the experimental condition were greater for the Odd-One-Out subtest ($M_{\text{Difference}}$ = -0.938,

$SD_{Difference}$ = 9.909, SE_{Mean} = 2.477), and the differences were not statistically significant ($F(1,15) = 0.143$, = .710, $\eta^2_{Partial}$ = .009, 1 – β = .065). The Mister X subtest score improved substantially under the experimental condition ($M_{Difference}$ = -3.563, $SD_{Difference}$ = 11.966, SE_{Mean} = 2.992) but the differences were not statistically significant and the effect size was not large ($F(1,15) = 1.418$, p = .252, $\eta^2_{Partial}$ = .086, 1 – β = .200). Slight declines in performance were observed for the Spatial Recall subtest ($M_{Difference}$ = 0.938, $SD_{Difference}$ = 7.380, SE_{Mean} = 1.845) but the statistics were small ($F(1,15) = 0.258$, p = .619, $\eta^2_{Partial}$ = .017, 1 – β = .258). The preliminary comparisons identified Listening Recall, Counting Recall and the Backwards Digit subtests as potentially differing significantly. However, as will be seen in later sections, the absolute value of the statistics of differences were substantially altered by the covariates. Average BAC was considered an essential covariate, forming the foundation of the study. Participant age and the "Stimulated" scale were both previously established as being intricately associated with average BAC levels. Earlier, a cursory examination of the RPM was conducted for its integrity in association with baseline scores on the AWMA, confirming the theoretical association. This applied only to the subtests in the visuo-spatial domain. Given the repeated measures design, test-retest delay was recorded and considered potentially important. The following sections give an overview of the interactions between test-retest delay, and the RPM, with the subtest difference scores. The repeated measures analysis of covariance models are presented prior to discussions in later sections.

Models and Interactions of Additional Covariates

The influence of test-retest delay on the repeated measures differences. The present research did not make use of a standard delay time between the baseline and experimental assessments but did adhere to a theorised minimum delay period of three-weeks and practical minimum delay of four-weeks. The average delay period was 87.38 days although this was subject to wide variation (SD = 52.59 days). This standard of delay is considered sufficient for psychometric assessments to avoid interference due to practice effects (Anastasi & Urbina, 1997). However, the potential for practice effects in any test-retest design, regardless of delay, is present. Saults et al.'s (2007) study utilising a test-retest paradigm made use of separate psychometric measures of the same construct which introduced an additional form of variance in favour of removal of practice effects. The present research favoured a delay procedure and repeated measures design but acknowledged the potential for residual practice effects. To assess the possible impact of this factor, correlation coefficients, and analysis of covariance models, inclusive of the interaction effects, were examined. These findings are presented in

Table 31. Since the correlation coefficients are represented of the interactions within models, they are discussed in detail in the subtest specific model sections. Positive correlation coefficients suggest a tendency towards deteriorations, or smaller improvements, in performance given longer test-retest delays. Test-retest delay was used as a covariate for all subtests due to its theoretical importance.

Table 31

Correlation Coefficients between Test-retest Delay Period and Repeated Measures Difference Scores on the AWMA (n = 16)

	Test-retest Delay	
	r	*p*
Digit Recall	-.165	.540
Word Recall	.206	.443
Nonword Recall	-.113	.678
Dot Matrix	-.447	.083
Mazes Memory	.093	.732
Block Recall	-.043	.875
Listening Recall	.245	.360
Counting Recall	.203	.451
Backwards Digit	.355	.177
Odd-one-out	.697**	.003
Mister X	.345	.190
Spatial Recall	.270	.312

* Significant at the 5% level
** Significant at the 1% level

Most of the subtest differences were not significantly correlated ($p > .05$) with the test delay period. This implies a lack of interaction in potential models. The direction and strength of the correlation coefficients varied with some being of medium strengths whilst most others were close to zero. The implications of these findings are clearer in sections discussing the specific subtest repeated measures analysis of covariance models. For a preliminary overview, Table 32 presents the model statistics for the repeated measures analyses of covariance which are referenced in the subtest specific sections.

Table 32:

AWMA Subtests Repeated Measures Analysis of Covariance Controlling for Test-retest Delay (n = 16)

	Model			*Model Statistics*				*Interaction Model*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	11.751	1	11.751	0.279	.605	.020	.078	16.571	1	16.571	0.394	.540	.027	.090	588.898	14	42.064
Word Recall	0.471	1	0.471	0.013	.910	.001	.051	21.987	1	21.987	0.623	.443	.043	.114	494.172	14	35.298
Nonword Recall	25.4	1	25.4	0.287	.600	.020	.079	15.913	1	15.913	0.18	.678	.013	.068	1238.609	14	88.472
Dot Matrix	62.481	1	62.481	1.098	.312	.073	.165	198.647	1	198.647	3.492	.083	.200	.413	796.353	14	56.882
Mazes Memory	31.981	1	31.981	0.224	.643	.016	.073	17.383	1	17.383	0.122	.732	.009	.062	1996.617	14	142.616
Block Recall	0.553	1	0.553	0.013	.912	.001	.051	1.138	1	1.138	0.026	.875	.002	.053	616.737	14	44.053
Listening Recall	183.407	1	183.407	3.152	.098	.184	.380	52.226	1	52.226	0.898	.360	.060	.143	814.649	14	58.189
Counting Recall	222.435	1	222.435	3.332	.089	.192	.398	40.215	1	40.215	0.602	.451	.041	.112	934.66	14	66.761
Backwards Digit	450.382	1	450.382	5.116	.040	.268	.558	177.783	1	177.783	2.02	.177	.126	.263	1232.436	14	88.031
Odd-One-Out	312.587	1	312.587	11.56	.004	.452	.885	357.901	1	357.901	13.236	.003	.486	.922	378.568	14	27.041
Mister X	220.685	1	220.685	3.267	.092	.189	.391	128.183	1	128.183	1.897	.190	.119	.250	945.786	14	67.556
Spatial Recall	11.41	1	11.41	0.422	.527	.029	.093	29.757	1	29.757	1.1	.312	.073	.165	378.712	14	27.051

* Type III Sum of Squares

The influence of the Raven's Progressive Matrices (Standard Form) on the repeated measures differences. The Raven's Progressive Matrices (Standard Form) (RPM) was implemented as a control variable to account for the possibility of an influence of non-verbal intelligence on the Visuo-spatial Short-term and Working Memory scores produced in the AWMA test. Earlier sections reported correlations between the RPM and the visuo-spatially focused baseline subtest measurements. This notion is theoretically supported (e.g. Ackerman et al., 2005; Colom et al., 2004; Conway et al., 2002). For consideration of interactions and influences, correlations between the repeated measures differences and the RPM were calculated and are shown in Table 33. Positive coefficients indicate an association between higher RPM scores and tendencies towards deterioration in repeated measures performance whilst negative coefficients indicate associations between higher RPM scores and tendencies towards improvements in performance. These correlations represent the basic interactions and are explored further in the full repeated measures models in later subtest specific sections.

Table 33

Correlation Coefficients between the RPM and the Repeated Measures Differences on the Visuo-spatial AWMA Subtests (n = 16)

	r	*p*
Dot Matrix	-.034	.900
Mazes Memory	.000	.999
Block Recall	.172	.523
Odd One Out	.514*	.041
Mr X	-.044	.870
Spatial Recall	.279	.296

* Significant at the 5% level

None of the assessments of visuo-spatial short-term memory showed statistically significant ($p > .05$) correlations between the difference scores and the RPM raw scores. A statistically significant correlation was present between differences on the Odd-one-out subtest and the RPM ($r = .514$, $p = .041$). The coefficient implies that higher scores on the RPM were associated with tendencies towards deteriorations in performance on the Odd-one-out subtest under the experimental condition. The Pearson's *r* values give a preliminary overview of the potential for interaction within a repeated measures model should the RPM be utilised as a covariate. Given prior findings, the RPM was included and responses to its control were compared. Table 34 gives a preliminary report of the inclusion of the RPM as a covariate, the details of which are reported in the subtest specific models.

Table 34

Visuo-spatial AWMA Subtests Repeated Measures Analysis of Covariance Controlling for the RPM (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	0.004	1	.004	0.000	.994	.000	.050	1.159	1	1.159	0.016	.900	.001	.052	993.841	14	70.989
Mazes Memory	4.674	1	4.674	0.032	.860	.002	.053	0.000	1	0.000	0.000	.999	.000	.050	2014.000	14	143.857
Block Recall	18.480	1	18.480	0.432	.522	.030	.094	18.380	1	18.380	0.429	.523	.030	.094	599.495	14	42.821
Odd-One-Out	200.934	1	200.934	5.194	.039	.271	.564	194.863	1	194.863	5.037	.041	.265	.551	541.606	14	38.686
Mister X	0.063	1	0.063	0.001	.977	.000	.050	2.118	1	2.118	0.028	.870	.002	.053	1071.851	14	76.561
Spatial Recall	27.891	1	27.891	1.037	.326	.069	.158	31.752	1	31.752	1.180	.296	.078	.173	376.717	14	26.908

* Type III Sum of Squares

The Influence of Alcohol on the Different Components of Working Memory: Full Models Accounting for the Covariates

The primary focus of the present research was the examination of the influence of alcohol on the different components of working memory in a repeated measures design. Findings suggested that average BAC values would be suitable for the analyses. Nonparametric alternatives to the statistical analyses reported here may have been more robust given the small sample size but none were available which would respond to the research question and data. However, the repeated measures analysis of covariance models for each BAC measurement point may be examined in Appendix H. The findings indicated important associations between average BAC and participant age (r = -.581, p = .018), average BAC and the derived "Stimulated" scale (r = .497, p = .050) and between participant age and the derived "Stimulated" scale (r = -.517, p = .050). These findings required the inclusion of participant age, and "Stimulated", as covariates. The previous two sections outlined the interactions, and models, associated with test-retest delay and the RPM scores. Although these findings were somewhat inconclusive, theoretical considerations implied a necessity for inclusion in all models for test-retest delay and in the visuo-spatially based models for the RPM scores. The previous review of the findings is detailed in-text in the appropriate sections to follow and the full models and interaction correlations can be reviewed in the two prior sections. The correlations between average BAC and the two covariates imply a complex influential analysis. Therefore, zero-order, partial, and semi-partial, correlation coefficients were examined as a component of the interaction and repeated measures analysis of variance models. The full correlation matrices, partial correlations and tables are reported in Appendix I and in-text in the appropriate sections to follow.

Verbal Short-term Memory. The Verbal Short-term Memory composite consisted of the Digit Recall, Word Recall and Nonword Recall subtests. The alterations in performance under the experimental condition were not statistically significant (p > .05) for any of the Verbal Short-term Memory subtests. The Verbal Short-term Memory subtest mean difference statistics were not significantly altered by the introduction of test-retest delay as a covariate. In some cases, the magnitude of the F, and partial eta squared, values was altered after the inclusion of the covariates. These changes indicate some impact of the covariate and were examined in conjunction with interaction effects. Prior to discussion of the subtest-specific models, the repeated measures analysis of covariance models accounting for average BAC, participant age and "Stimulated" are presented for reference purposes. Table 35 shows the

repeated measures analysis of covariance models controlling for average BAC while Table 36 shows the repeated measures analysis of covariance models controlling for participant age. Table 37 shows the repeated measures analysis of covariance models controlling for both average BAC and age in conjunction. The specifics, and relevance, of the findings are reported in conjunction with the full models in the subtest sections.

Tables 35, 36 and 37 demonstrate changes in the *F* statistics, and effect sizes, in comparison to the original repeated measures analysis of variance reported earlier in Table 30. The findings imply some influence of participant age alone and in conjunction with average BAC. Changes in the model statistics were also present when "Stimulated" was controlled for alone, shown in Table 38, and in conjunction with average BAC as shown in Table 39.

Table 35

Verbal Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	65.117	1	65.117	1.860	.194	.117	.246	115.396	1	115.396	3.297	.091	.191	.394	490.073	14	35.005
Word Recall	91.153	1	91.153	2.718	.121	.163	.336	46.627	1	46.627	1.390	.258	.090	.196	469.532	14	33.538
Nonword Recall	42.524	1	42.524	0.533	.478	.037	.105	136.555	1	136.555	1.710	.212	.109	.230	1117.967	14	79.855

* Type III Sum of Squares

Table 36

Verbal Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Participant Age (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	129.096	1	129.096	3.814	.071	.214	.444	131.563	1	131.563	3.887	.069	.217	.451	473.905	14	33.850
Word Recall	126.996	1	126.996	4.834	.045	.257	.535	148.343	1	148.343	5.646	.032	.287	.599	367.815	14	26.273
Nonword Recall	0.849	1	0.849	0.009	.924	.001	.051	0.289	1	0.289	0.003	.955	.000	.050	1254.233	14	89.588

* Type III Sum of Squares

Table 37

Verbal Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and Participant Age (n = 16)

		Model			*Model Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	Model	27.659	1	27.659	0.801	.387	.058	.132	448.764	13	34.520
	BAC	25.141	1	25.141	0.728	.409	.053	.124			
	Age	41.309	1	41.309	1.197	.294	.084	.174			
Word Recall	Model	75.420	1	75.420	2.666	.126	.170	.328	367.726	13	28.287
	BAC	0.089	1	0.089	0.003	.956	.000	.050			
	Age	101.806	1	101.806	3.599	.080	.217	.420			
Nonword Recall	Model	72.175	1	72.175	0.886	.364	.064	.141	1059.086	13	81.468
	BAC	195.147	1	195.147	2.395	.146	.156	.300			
	Age	58.881	1	58.881	0.723	.411	.053	.124			

* Type III Sum of Squares

Table 38

Verbal Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for "Stimulated" (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	15.244	1	15.244	0.362	.557	.025	.087	15.595	1	15.595	0.370	.553	.026	.088	589.874	14	42.134
Word Recall	75.384	1	75.384	2.294	.152	.141	.292	56.186	1	56.186	1.710	.212	.109	.230	459.973	14	32.855
Nonword Recall	0.229	1	0.229	0.003	.960	.000	.050	0.025	1	0.025	0.000	.987	.000	.050	1254.497	14	89.607

* Type III Sum of Squares

Table 39

Verbal Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and "Stimulated" (n = 16)

		Normal			*Stats model*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	Model	0.588	1	0.588	0.016	.902	.001	.052	487.520	13	37.502
	BAC	102.354	1	102.354	2.729	.122	.174	.334			
	"Stimulated"	2.553	1	2.553	0.068	.798	.005	.057			
Word Recall	Model	52.590	1	52.590	1.529	.238	.105	.209	447.173	13	34.398
	BAC	12.800	1	12.800	0.372	.552	.028	.087			
	"Stimulated"	22.359	1	22.359	0.650	.435	.048	.116			
Nonword Recall	Model	19.176	1	19.176	0.232	.638	.018	.073	1075.643	13	82.742
	BAC	178.854	1	178.854	2.162	.165	.143	.276			
	"Stimulated"	42.324	1	42.324	0.512	.487	.038	.102			

* Type III Sum of Squares

Tables 35 through 39 provided an overview of the models calculated comparing the baseline and experimental assessment mean scores on the Verbal Short-term Memory subtests of the AWMA controlling for the covariates identified for this section, namely, average breath alcohol concentration, age of participant and early feelings of "Stimulated". The previous sections showed the model statistics for every subtest controlling for the hypothetical covariates, test-retest delay and the RPM for the visuo-spatially based measurements. The next sections show the full model constructions for the Verbal Short-term Memory subtests to evaluate the influence of average BAC and influence of covariates on the introduction of this experimental variable.

Digit Recall. The slight improvement in performance on the Digit Recall subtest ($M_{\text{Difference}}$ = -0.063) was not statistically significant ($F(1,15) = 0.001$, $p = .978$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). Excluding the influence of average breath alcohol concentration resulted in a model which was not statistically significant but showed an increase in the magnitude of the *F* statistic ($F(1,14) = 1.860$, $p = .194$, $\eta^2_{Partial} = .117$, $1 - \beta = .246$). The moderate role of average BAC is evidenced by the effect size, and statistics, of the interaction effect ($F = 3.297$, $p = .091$, $\eta^2_{Partial} = .191$, $1 - \beta = .394$).

The interaction represents a positive correlation coefficient ($r = .437$, $p = .091$) implying a tendency towards deterioration in performance, or close to zero differences in performance, when average breath alcohol concentration levels are higher. Removal of the influence of average BAC resulted in a magnification of the statistical differences between the repeated measures means. Since age of participant and average BAC were statistically significantly correlated ($r = -.581$, $p = .018$), suggesting that younger participants recorded higher BAC

levels on average, age, rather than breath alcohol concentration, may have been partially responsible for this finding.

Participant age and the differences between the two assessment session means were moderately correlated (r = -.444, p = .085). Younger participants tended towards deteriorations in performance under the experimental conditions. A repeated measures analysis of covariance model, controlling for the influence of age from the Digit Recall mean differences, was approaching statistical significance (F(1,14) = 3.814, p = .071, $\eta^2_{Partial}$ = .214, 1 – β = .444) and also represented a substantial increase in F value over either the original analysis of variance model (F(1,15) = 0.001, p = .978, $\eta^2_{Partial}$ = .000, 1 – β = .050). The linear interaction effect approached statistical significance (F = 3.887, p = .069, $\eta^2_{Partial}$ = .217, 1 – β = .451).

The negative correlation coefficient (r = -.444, p = .085) suggests a tendency for younger persons to show deteriorations in performance, or less substantial improvements in performance, under the experimental condition. This finding suggested a role of participant age as a covariate in conjunction with average BAC values. However, a repeated measures analysis of covariance model excluding the influence of both age and average BAC showed a reduced F value in comparison to the other models (F(1,13) = 0.801, p = .387, $\eta^2_{Partial}$ = .058, 1 – β = .132), returning to similar statistics seen when no covariates were included. Furthermore, in this model, the interaction effect between the Digit Recall differences and participant age was not statistically significant (F = 1.197, p = .294, $\eta^2_{Partial}$ = .084, 1 – β = .174), nor was the interaction between the Digit Recall mean difference and average BAC (F = 0.728, p = .409, $\eta^2_{Partial}$ = .053, 1 – β = .124). When considered in context of the relationship between average BAC and the mean differences, with age as a potentially confounding variable, a partial correlation coefficient (r = .230, p = .409) indicated a weaker association than the zero-order coefficient (r = .437, p = .091). The semi-partial correlation coefficient (r = .204, p = .409) was similar, suggesting a lack of influence of age on the difference score. This finding shows a weakening of the association between average BAC and differences on the Digit Recall subtest repeated measures given the absence of the influence of participant age. The “Stimulated” scale, referring to the average of measurement points one through four on the “Stimulated” items of the B-BAES, was included as a covariate due to the original relationship observed to breath alcohol concentrations (r = .497, p = .050).

Removal of the influence of “Stimulated” from the analyses comparing the repeated measures means for the Digit Recall subtest did not result in a statistically significant model, which had similar statistics to the original analysis of variance model, (F(1,14) = 0.362, p =

.557, $\eta^2_{Partial}$ = .025, 1 – β = .087) and no statistically strong interaction effect was present (*F* = 0.370, *p* = .553, $\eta^2_{Partial}$ = .026, 1 – β = .088).

As a linear interaction, the correlation between the differences on the Digit Recall subtest and "Stimulated" was weak (*r* = .160, *p* = .553). Average BAC, correlated with "Stimulated" (*r* = .497, *p* = .050), was previously shown to have attenuated the magnitude of the mean differences. However, a repeated measures analysis of covariance model controlling for the influence of both average BAC and "Stimulated" had a similar *F* statistic to the single covariate model (*F*(1,13) = 0.016, *p* = .902, $\eta^2_{Partial}$ = .001, 1 – β = .052) and a weak interaction between the "Stimulated" scale and Digit Recall subtest differences (*F* = 0.650, *p* = .798, $\eta^2_{Partial}$ = .005, 1 – β = .057). The interaction between average BAC and the Digit Recall mean differences in this model had a substantial effect size (*F* = 2.729, *p* = .122, $\eta^2_{Partial}$ = .174, 1 – β = .334), suggesting an influence of breath alcohol concentration as a moderator of the strength of the mean differences. The influence of "Stimulated" on the relationship between average BAC and repeated measures differences on the Digit Recall subtest (*r* = .437, *p* = .091) was not substantially altered by removal of the influence of "Stimulated" using a partial correlation coefficient (*r* = .417, *p* = .122) or semi-partial correlation coefficient (*r* = .411, *p* = .122).

Exclusion of the influence of test-retest delay, as a potential indicator of the extent of possible practice effects, resulted in a slight increase in the model statistics (*F*(1,14) = 0.279, *p* = .605, $\eta^2_{Partial}$ = .020, 1 – β = .078). Furthermore, the interaction of the covariate within the model was weak (*F* = 0.394, *p* = .540, $\eta^2_{Partial}$ = .027, 1 – β = .090). The repeated measures differences on the Digit Recall subtest were not strongly correlated with test-retest delay but suggested that shorter delays could be slightly associated with deteriorations in performance (*r* = -.165, *p* = .540).

For the Digit Recall subtest, the magnitude of the statistics changed when separately controlling for the covariates identified as influential based on the separate models. The *F* statistics assessing the improvement in performance ($M_{\text{Difference}}$ = -0.063), and effect sizes, of the models were altered after instituting control for average BAC (*F*(1,14) = 1.860, *p* = .194, $\eta^2_{Partial}$ = .117, 1 – β = .246) and participant age (*F*(1,14) = 3.814, *p* = .071, $\eta^2_{Partial}$ = .214, 1 – β = .444). No substantial changes in the statistics were observed after control for "Stimulated" (*F*(1,14) = 0.362, *p* = .557, $\eta^2_{Partial}$ = .025, 1 – β = .087) or test-retest delay (*F*(1,14) = 0.279, *p* = .605, $\eta^2_{Partial}$ = .020, 1 – β = .078). The individual models both represented an increase in the magnitude of the statistics of difference in comparison to the original repeated measures

analysis of variance ($F(1,15) = 0.001$, $p = .978$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). Table 40 shows a repeated measures analysis of covariance model controlling for all of the covariates.

Table 40

Digit Recall Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	Model	36.924	1	36.924	0.947	.352	.079	.145	429.102	11	39.009
	BAC	35.265	1	35.265	0.904	.362	.076	.140			
	Age	58.341	1	58.341	1.496	.247	.120	.201			
	"Stimulated"	5.289	1	5.289	0.136	.720	.012	.063			
	Test-retest Delay	4.585	1	4.585	0.118	.738	.011	.061			

* Type III Sum of Squares

The repeated measures analysis of covariance model indicated no statistical importance of the differences on the Digit Recall subtest. Small statistical values, including the effect size, and no statistical significance was present ($F(1,11) = 0.947$, $p = .352$, $\eta^2_{Partial} = .079$, $1 - \beta = .145$). The interactions showed that participant age was responsible for the most linear influence on the differences as a covariate ($F = 1.496$, $p = .247$, $\eta^2_{Partial} = .120$, $1 - \beta = .201$). The medium effect size suggests some contribution of participant age. Small effect sizes were observed for the interactions for average BAC ($F = 0.904$, $p = .362$, $\eta^2_{Partial} = .076$, $1 - \beta = .140$), "Stimulated" ($F = 0.136$, $p = .720$, $\eta^2_{Partial} = .012$, $1 - \beta = .063$) and test-retest delay ($F = .118$, $p = .738$, $\eta^2_{Partial} = .011$, $1 - \beta = .061$). The findings indicate that although the covariates, particularly participant age, played some role in attenuating the true differences over the repeated measures of the Digit Recall subtest, no statistically important differences existed between the baseline and experimental measures without the influence of these covariates or with all the covariates. Table 41 shows the repeated measures analysis of covariance excluding the covariates but permitting the inclusion of influence from average BAC in response to the research question for comparative purposes.

Table 41

Digit Recall Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	Model	68.600	1	68.600	1.773	.208	.129	.232	464.367	12	38.697
	Age	121.676	1	121.676	3.144	.102	.208	.372			
	"Stimulated"	0.845	1	0.845	0.022	.885	.002	.052			
	Test-retest Delay	4.201	1	4.201	0.109	.747	.009	.061			

* Type III Sum of Squares

Allowing the influence of average BAC to impact the comparisons, the repeated measures analysis of covariance model was not statistically significant, but a medium effect size was present ($F(1,12) = 1.773$, $p = .208$, $\eta^2_{Partial} = .129$, $1 - \beta = .232$). In comparison to the previous models, a substantial increase in the *F* statistic was observed. Participant age proved influential as a covariate ($F = 3.144$, $p = .102$, $\eta^2_{Partial} = .208$, $1 - \beta = .372$) but this was not the case for "Stimulated" ($F = 0.022$, $p = .885$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$) or test-retest delay ($F = 0.109$, $p = .747$, $\eta^2_{Partial} = .009$, $1 - \beta = .061$).

Comparisons of the various models suggests that sources of covariation were important and that the influence of average BAC was substantial in creating the repeated measures differences when these covariates were accounted for. Furthermore, although participant age appeared to magnify the relationship between average BAC and differences on the Digit Recall subtest, "Stimulated" did not have such an effect. The influence of participant age was also reflected in the interactions within the models, emphasising the complexity of association with average BAC in this case.

Word Recall. Performance on the Word Recall subtest deteriorated under the experimental condition ($M_{\text{Difference}} = 2.363$) but the repeated measures analysis of variance model was not statistically significant ($F(1,15) = 1.298$, $p = .273$, $\eta^2_{Partial} = .080$, $1- \beta = .187$). When the influence of average BAC was excluded from the model, the value of the *F* statistic increased substantially ($F(1,14) = 2.718$, $p = .121$, $\eta^2_{Partial} = .163$, $1 - \beta = .336$). However, the linear interaction effect between the covariate and the differences was not large ($F = 1.390$, $p = .258$, $\eta^2_{Partial} = .080$, $1 - \beta = .196$).

The interaction shows a negative correlation coefficient between average BAC and the differences between the repeated measures means on the Word Recall subtest ($r = -.301$, $p = .258$). The negative correlation coefficient implies a tendency towards improvement under experimental conditions given higher average BAC readings. As discussed, participant age and average BAC were statistically correlated ($r = -.581$, $p = .018$) indicating higher average BAC readings associated with younger individuals, making participant age a closely related second covariate.

The repeated measures analysis of covariance model, excluding the influence of participant age on the mean differences, was statistically significant and, in comparison to the original analysis of variance, showed a considerable increase in statistical values ($F(1,14) = 4.834$, $p = .045$, $\eta^2_{Partial} = .257$, $1 - \beta = .535$). Furthermore, a statistically significant interaction effect was present ($F = 5.646$, $p = .032$, $\eta^2_{Partial} = .287$, $1 - \beta = .599$), suggesting a linear

relationship to the covariate. Participant age at first assessment was statistically significantly correlated with differences on the Word Recall subtest (r = .536, p = .032) suggesting a useful linear regression model relationship in which older participants tended towards deteriorations in performance under the experimental condition despite a tendency towards lower average BAC values.

Combining the influence of these closely related covariates, a repeated measures analysis of covariance model excluding variance introduced by both average BAC and participant age was not statistically significant (F(1,13) = 2.666, p = .126, $\eta^2_{Partial}$ = .170, 1 – β = .328). The effect size was large. The statistical values were similar to the model controlling for only average BAC but reduced in comparison to the model excluding the influence of participant age alone. The interaction for the covariate average BAC was negligible (F = 0.003, p = .956, $\eta^2_{Partial}$ = .000, 1 – β = .050) but that for participant age was quite substantial (F = 3.599, p = .080, $\eta^2_{Partial}$ = .217, 1 – β = .420). The findings imply that participant age had a substantial impact on the repeated measures differences for the Word Recall subtest, perhaps through influence of the average BAC to repeated measures differences relationship. The zero-order correlation between average BAC and differences on the Word Recall subtest repeated measures (r = -.301, p = .258) tended towards zero when the influence of participant age was excluded by calculating a partial correlation coefficient (r = .016, p = .956) and semi-partial coefficient (r = .013, p = .956). The shift towards a positive correlation, achieving a null relationship, suggests an attenuating influence of participant age on the relationship, potentially confounding the true direction of association between the two variables. Participant age was also correlated with the "Stimulated" scale (r = -.517, p = .040) which, in turn, was positively associated with average BAC (r = .497, p = .050).

When "Stimulated" was controlled for, the repeated measures analysis of covariance model for the Word Recall subtest was not statistically significant although the effect size was quite substantial (F(1,14) = 2.294, p = .152, $\eta^2_{Partial}$ = .141, 1 – β = .292). Like the model controlling for participant age, a substantial improvement in the F statistic over the original model was evident (F(1,15) = 1.298, p = .273, $\eta^2_{Partial}$ = .080, 1- β = .187). The interaction suggested some influence of "Stimulated" on the mean differences (F = 1.710, p = .109, $\eta^2_{Partial}$ = .109, 1 – β = .230). A negative correlation between "Stimulated" and the repeated measures differences on the Word Recall subtest was present (r = -.330, p = .553), suggesting that individuals agreeing with the "Stimulated" items during points one through four of the experimental assessment tended towards improvements in performance in comparison to the

baseline assessment. Based on the previously mentioned associations between average BAC and "Stimulated" (r = .497, p = .050), and the findings of the repeated measures analysis of covariance model excluding the influence of average BAC, the combined impact of the two covariates can be considered.

The repeated measures analysis of covariance model controlling for both average BAC and "Stimulated" was similar to the original analysis of variance model in the magnitude of the statistics, and statistical significance, (F(1,13) = 1.529, p = .238, $\eta^2_{Partial}$ = .105, 1 – β = .209) with interaction effects lacking in linear explanatory power for both average BAC (F = 0.372, p = .552, $\eta^2_{Partial}$ = .028, 1 – β = .087) and "Stimulated" (F = 0.650, p = .435, $\eta^2_{Partial}$ = .048, 1 – β = .116). The models analysed did not show a strong influence of the covariates in producing the repeated measures differences. The correlational relationship between differences on the Word Recall subtest and average BAC (r = -.301, p = .258) was influenced by the "Stimulated" scale, tending towards a lesser negative association based on a partial correlation coefficient (r = -.167, p = .552) and semi-partial coefficient (r = -.157, p = .552). The lack of difference between the coefficients suggests only a small influence of "Stimulated" on the relationship between average BAC and differences on the Word Recall subtest.

When the influence of test-retest delay was controlled for, the repeated measures analysis of covariance model for the Word Recall subtest was not statistically significant and illustrated a reduction in model statistics (F(1,14) = 0.013, p = .910, $\eta^2_{Partial}$ = .001, 1 – β = .051). Test-retest delay did not linearly interact with the Word Recall subtest repeated measures differences within the model (F = 0.623, p = .443, $\eta^2_{Partial}$ = .043, 1 – β = .114). The slight positive direction of the correlation coefficient between the Word Recall differences and test-retest delay (r = .206, p = .443) suggests that longer test-retest delays were associated with deteriorations in performance under the experimental condition.

The original repeated measures analysis of covariance statistics for the Word Recall subtest (F(1,15) = 1.298, p = .273, $\eta^2_{Partial}$ = .080, 1- β = .187) were inflated by control for the influence of average BAC (F(1,14) = 2.718, p = .121, $\eta^2_{Partial}$ = .163, 1 – β = .336), participant age (F(1,14) = 4.834, p = .045, $\eta^2_{Partial}$ = .257, 1 – β = .535) and "Stimulated" (F(1,14) = 2.294, p = .152, $\eta^2_{Partial}$ = .141, 1 – β = .292). However, control for the influence of test-retest delay resulted in a reduction in the statistical values (F(1,14) = 0.013, p = .910, $\eta^2_{Partial}$ = .001, 1 – β = .051). The changes in the F statistics, and effect sizes, implies some influence of the covariates on the assessment of the repeated measures differences within the models. A model controlling for all identified sources of covariation is shown in Table 42.

Table 42

Word Recall Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			Statistics				Error		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Word Recall	Model	24.604	1	24.604	0.774	.398	.066	.127	349.527	11	31.775
	BAC	0.440	1	0.440	0.014	.908	.001	.051			
	Age	96.792	1	96.792	3.046	.109	.217	.357			
	"Stimulated"	11.056	1	11.056	0.348	.567	.031	.084			
	Test-retest Delay	15.791	1	15.791	0.497	.495	.043	.099			

* Type III Sum of Squares

The original repeated measures analysis of variance model assessing the repeated measures differences ($M_{\text{Difference}}$ = 2.363) was not statistically significant ($F(1,15) = 1.298$, p = .273, $\eta^2_{Partial}$ = .080, 1- β = .187). Removal of the sources of extraneous variance in the finalised model resulted in a small reduction in the model statistics ($F(1,11) = 0.774$, p = .398, $\eta^2_{Partial}$ = .066, 1 – β = .127). The covariate participant age interacted strongly, in terms of effect size, within the model (F = 3.046, p = .109, $\eta^2_{Partial}$ = .217, 1 – β = .357) whilst interaction statistics were small for average BAC (F = 0.014, p = .908, $\eta^2_{Partial}$ = .001, 1 – β = .051), "Stimulated" (F = 0.348, p = .567, $\eta^2_{Partial}$ = .031, 1 – β = .084) and test-retest delay (F = 0.497, p = .495, $\eta^2_{Partial}$ = .043, 1 – β = .099). However, the statistics were altered when the influence of average BAC was permitted. These statistics are shown in Table 43.

Table 43

Word Recall Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			Statistics				Error		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Word Recall	Model	24.961	1	24.961	0.856	.373	.067	.137	349.967	12	29.164
	Age	109.906	1	109.906	3.769	.076	.239	.431			
	"Stimulated"	10.633	1	10.633	0.365	.557	.029	.086			
	Test-retest Delay	15.877	1	15.877	0.544	.475	.043	.104			

* Type III Sum of Squares

The repeated measures analysis of covariance model statistics for the model including variance introduced by average BAC were not substantially different to those for other models ($F(1,12) = 0.856$, p = .373, $\eta^2_{Partial}$ = .067, 1 – β = .137). Participant age, as a covariate, had a strong interaction with the differences within the model (F = 3.769, p = .076, $\eta^2_{Partial}$ = .239, 1 – β = .431) implying considerable linear influence in predicting the repeated measures differences. This may have been partially due to the tendency for participant age to enhance a negative association between average BAC and the repeated measures differences which rather tended towards a zero-magnitude coefficient without this influence. However, this was not true

of "Stimulated" (F = 0.365, p = .557, $\eta^2_{Partial}$ = .029, 1 – β = .086) or test-retest delay (F = 0.544, p = .475, $\eta^2_{Partial}$ = .043, 1 – β = .104). The influence of variance introduced by average BAC was not substantial for the Word Recall subtest deterioration in performance ($M_{\text{Difference}}$ = 2.363) but participant age did have a considerable influence on the model statistics as a linear covariate.

Nonword Recall. The original comparison of the changes in performance on the Nonword Recall assessment ($M_{\text{Difference}}$ = 1.119) showed that the deterioration was not statistically significant, and a small effect size was calculated (F(1,15) = 0.120, p = .734, $\eta^2_{Partial}$ = .008, 1 – β = .062). Control for average BAC levels did not result in a considerable change in the F statistic, or effect size, of the model (F(1,14) = 0.533, p = .478, $\eta^2_{Partial}$ = .037, 1 – β = .105) although the interaction effect suggested some possibility of influence of the covariate on the difference (F = 1.710, p = .212, $\eta^2_{Partial}$ = .109, 1 – β = .230). The interaction shows a positive correlation between average BAC and the repeated measures differences on the Nonword Recall subtest (r = .330, p = .212). This finding implies that larger average BAC values were associated with deteriorations in performance under the experimental condition. As noted for the other Verbal Short-term Memory subtests, there is some evidence that the inclusion of average BAC masked the magnitude of difference between the two subtest conditions. despite the correlation between average BAC and participant age (r = -.581, p = .018).

The lack of contribution to the variance by age of participant was evidenced in a lack of change in the F statistic of the analysis of covariance model by control for this variable (F(1,14) = 0.009, p = .924, $\eta^2_{Partial}$ = .001, 1 – β = .051) and a negligible interaction effect was calculated (F = 0.003, p = .955, $\eta^2_{Partial}$ = .000, 1 – β = .050). The correlational statistics and interaction effect imply a lack of linear influence of participant age on the observed repeated measures differences on the Nonword Recall subtest (r = -.015, p = .955).

Removal of the influence of both average BAC and participant age also did not result in an improvement in the magnitude of the model statistics (F(1,13) = 0.886, p = .364, $\eta^2_{Partial}$ = .064, 1 – β = .141). However, removal of the influence of both variables further magnified the influence of an interaction of average BAC within the model (F = 2.395, p = .146, $\eta^2_{Partial}$ = .156, 1 – β = .300) without successfully incorporating the interaction of age of participant (F = 0.723, p = .411, $\eta^2_{Partial}$ = .053, 1 – β = .124). Age of participant, in this case, did not appear to have an influence on the relationship between average BAC and differences on the Nonword Recall subtest. The zero-order correlation coefficient between average BAC and the Nonword

Recall subtest repeated measures differences (r = .330, p = .212) was not substantially altered by the removal of the influence of participant age based on a partial correlation coefficient (r = .394, p = .146) or semi-partial correlation coefficient (r = .394, p = .146). Findings examining the impact of "Stimulated" on the mean differences were similar in magnitude to those for "Age", suggesting that differences on the Nonword Recall subtest may have been attenuated by average BAC alone, without considerable influence from either of these covariates.

When "Stimulated" was controlled for, the magnitude of the F statistic was not substantially altered (F(1,14) = 0.003, p = .960, $\eta^2_{Partial}$ = .000, 1 – β = .050). The interaction effect did not suggest a linear influence of the "Stimulated" scale on the Nonword Recall repeated measures differences (F = 0.000, p = .987, $\eta^2_{Partial}$ = .000, 1 – β = .050). The correlation coefficient, illustrating the interaction effect, was close to zero (r = .004, p = .987). The "Stimulated" scale alone did not appear to substantially influence the statistical magnitude of the repeated measures differences for Nonword Recall.

Despite the close association between "Stimulated" and average BAC (r = .497, p = .050), a repeated measures analysis of covariance model controlling for the influence of both covariates did not show substantial increase in statistical magnitude in comparison to the original analysis of variance model (F(1,13) = 0.232, p = .638, $\eta^2_{Partial}$ = .018, 1 – β = .073). The "Stimulated" scale, in this model, had a negligible interaction as a linear model to the difference values (F = 0.512, p = .487, $\eta^2_{Partial}$ = .038, 1 – β = .102). However, this model's interaction effect for average BAC had a substantial effect size (F = 2.162, p = .165, $\eta^2_{Partial}$ = .143, 1 – β = .276). In the relationship between average BAC and the repeated measures Nonword Recall subtest mean differences, removal of the influence of "Stimulated" using a partial correlation coefficient (r = .378, p = .165), and semi-partial correlation coefficient (r = .378, p = .165), suggested a slight strengthening in comparison to the zero-order coefficient (r = .330, p = .212).

Test-retest delay was not influential in the repeated measures analysis of covariance for Nonword Recall (F(1,14) = 0.287, p = .600, $\eta^2_{Partial}$ = .020, 1 – β = .079). The model statistics were similar to those calculated for the repeated measures analysis of variance inclusive of this source of variance (F(1,15) = 0.120, p = .734, $\eta^2_{Partial}$ = .008, 1 – β = .062). The interaction of the covariate to the differences on the Nonword Recall subtest was not statistically large (F = 0.180, p = .678, $\eta^2_{Partial}$ = .013, 1 – β = .068). The interaction is also illustrating the correlation coefficient which suggested that shorter delays, in days, were associated with deteriorations in

performance under the experimental condition rather than the expected improvements (r = -.113, p = .678).

The findings, based on calculations over the repeated measures of the Nonword Recall subtest, suggest little influence of the covariates in relation to the repeated measures differences observed ($M_{\text{Difference}}$ = 1.119). The deterioration in performance was not statistically significant ($F(1,15) = 0.120$, p = .734, $\eta^2_{Partial}$ = .008, 1 – β = .062) and minimal changes to the statistics were observed in separate models account for control of average BAC ($F(1,14) = 0.533$, p = .478, $\eta^2_{Partial}$ = .037, 1 – β = .105), participant age ($F(1,14) = 0.009$, p = .924, $\eta^2_{Partial}$ = .001, 1 – β = .051), "Stimulated" ($F(1,14) = 0.003$, p = .960, $\eta^2_{Partial}$ = .000, 1 – β = .050) or test-retest delay ($F(1,14) = 0.287$, p = .600, $\eta^2_{Partial}$ = .020, 1 – β = .079). The model calculated, assessing the repeated measures variance without the influence of any identified covariates, is shown in Table 44.

Table 44

Nonword Recall Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Nonword Recall	Model	8.607	1	8.607	0.093	.766	.008	.059	1015.162	11	92.287
	BAC	210.884	1	210.884	2.285	.159	.172	.282			
	Age	51.658	1	51.658	0.560	.470	.048	.105			
	"Stimulated"	38.697	1	38.697	0.419	.531	.037	.091			
	Test-retest Delay	25.823	1	25.823	0.280	.607	.025	.077			

* Type III Sum of Squares

The repeated measures analysis of covariance model had small statistics, similar to those of the repeated measures analysis of variance originally conducted, which were not statistically significant ($F(1,11) = 0.093$, p = .766, $\eta^2_{Partial}$ = .008, 1 – β = .059). However, average BAC did interact substantially within the model repeated measures differences (F = 2.285, p = .159, $\eta^2_{Partial}$ = .172, 1 – β = .282). The same was not true of participant age (F = 0.560, p = .470, $\eta^2_{Partial}$ = .048, 1 – β = .105), "Stimulated" (F = 0.419, p = .531, $\eta^2_{Partial}$ = .037, 1 – β = .091) or test-retest delay (F = 0.280, p = .607, $\eta^2_{Partial}$ = .025, 1 – β = .077). The findings suggest that with, or without, the influence of the covariates, no statistically important changes were observed for the Nonword Recall subtest. Exclusion of the influence of the extraneous covariates whilst permitting influence from average BAC in a repeated measures analysis of covariance model resulted in the model statistics presented in Table 45.

Table 45

Nonword Recall Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Nonword Recall	Model	2.467	1	2.467	0.024	.879	.002	.052	1226.046	12	102.171
	Age	1.874	1	1.874	0.018	.895	.002	.052			
	"Stimulated"	8.190	1	8.190	0.080	.782	.007	.058			
	Test-retest Delay	28.167	1	28.167	0.276	.609	.022	.077			

* Type III Sum of Squares

No substantial differences in the model statistics were observed when the variance of average BAC was included in the calculations ($F(1,12) = 0.024$, $p = .879$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$). The earlier correlational analyses also suggested an absence of influence of participant age, or "Stimulated" on the zero-order relationship between average BAC and the differences on the Nonword Recall subtest. None of the covariates had strong calculated linear interactions with small effect sizes and high probability values of the linear interaction being calculated for participant age ($F = 0.018$, $p = .895$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$), "Stimulated" ($F = 0.080$, $p = .782$, $\eta^2_{Partial} = .007$, $1 - \beta = .058$) and test-retest delay ($F = 0.276$, $p = .609$, $\eta^2_{Partial} = .022$, $1 - \beta = .077$). The repeated measures deterioration on the Nonword Recall subtest ($M_{\text{Difference}} = 1.119$) did not seem to be substantially influenced by any of the covariates, or the introduction of alcohol under the experimental condition. However, when the influence of other covariates was excluded, the influence of alcohol did have some linear impact.

Verbal Working Memory. The Verbal Working Memory composite consisted of the Listening Recall subtest, Listening Recall Processing score, Counting Recall subtest, Counting Recall Processing score and Backwards Digit subtest. Medium to large partial eta squared values were calculated for all the Verbal Working Memory subtests. Performances improved under the experimental condition and the Counting Recall components differed statistically significantly ($p < .05$) whilst the Listening Recall subtest only, and Backwards Digit subtest, approached statistical significance ($p < .08$). As mentioned in earlier sections, the variable "Age" was significantly correlated with average breath alcohol concentration ($r = -.581$, $p = .018$), leading to its inclusion as a covariate. The summative scale of agreement with the items measuring stimulation on the B-BAES from points one through four of measurement, "Stimulated" was included as a covariate on theoretical grounds as well as the statistically significant correlation with average BAC ($r = .497$, $p = .050$). Participant age and "Stimulated" were also statistically significantly correlated ($r = -.517$, $p = .040$), bolstering the necessity for the inclusion of all three theoretical covariates. Correlation coefficients, including partial

coefficients, between the difference scores and these covariates are shown in Appendix I and discussed in-text where appropriate. Test-retest delay was also considered due to potential influence but the RPM was excluded based on preliminary findings. Table 46 shows the repeated measures analysis of covariance models controlling for average BAC while Table 47 shows the repeated measures analysis of covariance models controlling for participant age and Table 48 shows the repeated measures analysis of covariance models controlling for both average BAC and age.

As Table 47 and 48 show, some substantial values for partial eta squared, and statistically significant models and effects, were calculated after the exclusion of participant age, particularly in association with exclusion of average breath alcohol concentrations. Changes were evident when compared to the *F* statistics presented for the analysis of variance models described at during the preliminary analyses. When “Stimulated” was controlled for, other changes were identified, as shown in Table 49 and Table 50.

Table 46

Verbal Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC (n = 16)

	Normal			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	148.946	1	148.946	2.436	.141	.148	.307	11.016	1	11.016	0.180	.678	.013	.068	855.859	14	61.133
Counting Recall	328.185	1	328.185	4.998	.042	.263	.548	55.524	1	55.524	0.846	.373	.057	.138	919.351	14	65.668
Backwards Digit	317.884	1	317.884	3.256	.093	.189	.390	43.328	1	43.328	0.444	.516	.031	.095	1366.891	14	97.635

* Type III Sum of Squares

Table 47

Verbal Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Participant Age (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	68.716	1	68.716	1.168	.298	.077	.172	43.074	1	43.074	0.732	.407	.050	.126	823.801	14	58.843
Counting Recall	1.667	1	1.667	0.024	.879	.002	.052	1.025	1	1.025	0.015	.905	.001	.051	973.850	14	69.561
Backwards Digit	416.570	1	416.570	5.403	.036	.278	.581	330.747	1	330.747	4.290	.057	.235	.488	1079.471	14	77.105

* Type III Sum of Squares

Table 48

Verbal Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and Participant Age (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	Model	144.099	1	144.099	2.507	.137	.162	.311	747.112	13	57.470
	BAC	76.689	1	76.689	1.334	.269	.093	.188			
	Age	108.747	1	108.747	1.892	.192	.127	.247			
Counting Recall	Model	42.486	1	42.486	0.612	.448	.045	.112	902.779	13	69.445
	BAC	71.071	1	71.071	1.023	.330	.073	.155			
	Age	16.572	1	16.572	0.239	.633	.018	.074			
Backwards Digit	Model	853.964	1	853.964	17.451	.001	.573	.971	636.165	13	48.936
	BAC	443.306	1	443.306	9.059	.010	.411	.794			
	Age	730.726	1	730.726	14.932	.002	.535	.946			

* Type III Sum of Squares

Table 49

Verbal Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Models Controlling for "Stimulated" (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	56.397	1	56.397	0.935	.350	.063	.147	22.101	1	22.101	0.366	.555	.025	.087	844.774	14	60.341
Counting Recall	43.026	1	43.026	0.623	.443	.043	.114	8.201	1	8.201	0.119	.735	.008	.062	966.674	14	69.048
Backwards Digit	1.181	1	1.181	0.012	.915	.001	.051	25.495	1	25.495	0.258	.620	.018	.076	1384.724	14	98.909

* Type III Sum of Squares

Table 50

Verbal Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Models Controlling for Average BAC and "Stimulated" (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Observed Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	Model	46.886	1	46.886	0.723	.411	.053	.124	843.489	13	64.884
	BAC	1.285	1	1.285	0.020	.890	.002	.052			
	"Stimulated"	12.370	1	12.370	0.191	.670	.014	.069			
Counting Recall	Model	17.931	1	17.931	0.254	.623	.019	.075	918.420	13	70.648
	BAC	48.254	1	48.254	0.683	.423	.050	.120			
	"Stimulated"	0.931	1	0.931	0.013	.910	.001	.051			
Backwards Digit	Model	16.892	1	16.892	0.172	.685	.013	.067	1275.021	13	98.079
	BAC	109.702	1	109.702	1.119	.309	.079	.165			
	"Stimulated"	91.870	1	91.870	0.937	.351	.067	.146			

* Type III Sum of Squares

Considerable changes in *F* values were observed when both average BAC and "Stimulated" were controlled for. This finding was true across all the Verbal Working Memory subtests examined and contrasts the models in Table 49 where only "Stimulated" was controlled for. This finding implies some potential for an important co-dependent relationship between physiological and subjective intoxication. The following sections examine the findings for each subtest, and the composite score, in relation to the other analyses incorporating the influence of all variables.

Listening Recall. The Listening Recall subtest mean score was substantially higher under the experimental condition ($M_{\text{Difference}}$ = -5.125), implying improvements in performance due to some variable. A repeated measures analysis of variance model approached statistical significance with a large effect size ($F(1,15) = 6.636$, $p = .076$, $\eta^2_{Partial} = .195$, $1 - \beta = .431$). The value of the *F* statistic reduced substantially when average BAC was controlled for, although the effect size was still quite substantial ($F(1,14) = 2.436$, $p = .141$, $\eta^2_{Partial} = .148$, $1 - \beta = .307$). This finding implies a magnification of the statistics of difference through variance introduced by average BAC values. This association did not appear to be purely linear as the repeated measures analysis of covariance model interaction effect was not statistically significant and only a small effect size was calculated ($F = 0.180$, $p = .678$, $\eta^2_{Partial} = .013$, $1 - \beta = .068$). The interaction, also understood by the correlation between average breath alcohol concentration and the differences in the Listening Recall subtest scores over the two conditions ($r = .113$, $p = .678$), suggested a slight tendency for individuals with larger average BAC readings to perform less well during the experimental condition. The association between younger participant ages and higher average BAC readings ($r = -.581$, $p = .018$) may also have

influenced the calculation of the statistics of difference in the repeated measures analyses of covariance.

Although participant age was not statistically significantly correlated with the repeated measures differences on the Listening Recall subtest (r = .223, p = .407), changes were seen in the F statistic of the model when the influence of participant age values was removed from the repeated measures differences calculations (F(1,14) = 1.168, p = .298, $\eta^2_{Partial}$ = .077, 1 – β = .172). In this case, the value of the F statistic, and associated effect size, reduced in comparison to the analysis of variance model (F(1,15) = 6.636, p = .076, $\eta^2_{Partial}$ = .195, 1 – β = .431). The change implied some influence of participant age in magnifying the statistical values for the calculated repeated measures differences. The interaction between participant age and differences on the Listening Recall assessment within the model was not statistically large (F = 0.732, p = .407, $\eta^2_{Partial}$ = .050, 1 – β = .126). The slight positive correlation (r = .223, p = .407) between participant age and Listening Recall baseline to experimental differences implied a weak correlation between higher ages and a tendency towards deteriorations in performance under the experimental condition.

Older participants tended to have lower BAC readings (r = -.581, p = .018) suggesting an interlinking of average BAC and participant age as covariates. Exclusion of the influence of both variables resulted in a reduction in the F statistic in comparison to the original model (F(1,13) = 2.507, p = .137, $\eta^2_{Partial}$ = .162, 1 – β = .311), suggesting some importance of both in the production of the original differences. Examination of the interaction effects for the two covariate models suggests a larger influence of participant age (F = 1.892, p = .192, $\eta^2_{Partial}$ = .127, 1 – β = .247) and less influence of average BAC (F = 1.334, p = .269, $\eta^2_{Partial}$ = .093, 1 – β = .188). The correlation between participant age and Listening Recall subtest differences was not statistically significant (r = .223, p = .407), nor was the zero-order correlation coefficient between average BAC and the Listening Recall subtest differences (r = .113, p = .678). However, removal of the influence of the variable “Age” from the association between average BAC and differences in performance on the Listening Recall subtest over the repeated measures resulted in a substantial increase in strength of association based on both the partial correlation coefficient (r = .305, p = .269), and semi-partial correlation coefficient (r = .297, p = .269). Inclusion of variance from average BAC and participant age appeared to magnify the statistics of difference calculated for the repeated measures on the Listening Recall subtest. The correlation between “Stimulated” and average BAC (r = .497, p = .050), and participant age (r = -.517, p = .040), implied potential for a similar influence as a covariate.

Whilst the *F* statistic for the analysis of variance model comparing the repeated measures on the Listening Recall subtest was approaching statistical significance ($F(1,15) = 6.636$, $p = .076$, $\eta^2_{Partial} = .195$, $1 - \beta = .431$), statistical values when the influence of "Stimulated" was excluded were substantially lower ($F(1,14) = 0.935$, $p = .350$, $\eta^2_{Partial} = .063$, $1 - \beta = .147$) implying a role of subjective stimulation during the early portions of the assessment in magnifying the differences between the means. The "Stimulated" scale did not have a substantial linear influence on the repeated measures differences for the Listening Recall subtest ($F = 0.363$, $p = .555$, $\eta^2_{Partial} = .025$, $1 - \beta = .087$), also illustrated by the weak correlation coefficient ($r = .160$, $p = .555$). The positive correlation between "Stimulated" and the repeated measures differences on the Listening Recall subtest ($r = .160$, $p = .555$) implied a slight tendency for those reporting higher levels of "Stimulated" on early B-BAES measurements to experience deteriorations in performance under the experimental condition.

When the influence of both average BAC and "Stimulated" were controlled for the value of the statistic and effect size reduced further ($F(1,13) = 0.723$, $p = .411$, $\eta^2_{Partial} = .053$, $1 - \beta = .124$). Small interaction effects were calculated for the model's associations between the Listening Recall subtest mean differences and average BAC ($F = 0.020$, $p = .890$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$) and "Stimulated" ($F = 0.191$, $p = .670$, $\eta^2_{Partial} = .014$, $1 - \beta = .069$). These findings are consistent with the reduction in the strength of relationship between average BAC and the differences on the Listening Recall subtest ($r = .113$, $p = .678$) when "Stimulated" value influences were removed from both variables through a partial correlation coefficient ($r = .039$, $p = .890$), and average BAC alone through a semi-partial correlation coefficient ($r = .039$, $p = .890$).

Control for test-retest delay in the repeated measures analysis of covariance model for the Listening Recall subtest slightly reduced the magnitude of the *F* statistic, and effect size, ($F(1,14) = 3.152$, $p = .098$, $\eta^2_{Partial} = .184$, $1 - \beta = .380$). However, the linear interaction of the covariate within the differences model was not statistically strong ($F = 0.898$, $p = .360$, $\eta^2_{Partial} = .060$, $1 - \beta = .143$). The findings imply low impact of test-retest delay on differences on the repeated measures. This was also reflected in the correlation coefficient ($r = .245$, $p = .360$). Although the linear interaction was not statistically significant, some tendency towards deteriorations in performance was observed when test-retest delays were longer.

The findings for the Listening Recall subtest suggest that the repeated measures differences ($M_{\text{Difference}} = -5.125$) were slightly magnified through the inclusion of variance from participant age and congruence with "Stimulated", resulting in a model approaching statistical

significance ($F(1,15) = 6.636$, $p = .076$, $\eta^2_{Partial} = .195$, $1 - \beta = .431$). There was a reduction in the magnitude of the model statistics following the separate exclusion of participant age ($F(1,14) = 1.168$, $p = .298$, $\eta^2_{Partial} = .077$, $1 - \beta = .172$), "Stimulated" ($F(1,14) = 0.935$, $p = .350$, $\eta^2_{Partial} = .063$, $1 - \beta = .147$) and test-retest delay ($F(1,14) = 3.152$, $p = .098$, $\eta^2_{Partial} = .184$, $1 - \beta = .380$). The findings imply a magnifying effect of those covariates separately. Table 51 presents a model of a repeated measures analysis of covariance controlling for the influence of all the covariates, including average BAC as the hypothetically causative factor.

Table 51

Listening Recall Repeated Measures Analysis of Covariance Models Controlling for Average BAC, Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Listening Recall	Model	240.200	1	240.200	4.571	.056	.294	.496	578.039	11	52.549
	Bac	42.435	1	42.435	0.808	.388	.068	.130			
	Age	67.359	1	67.359	1.282	.282	.104	.179			
	"Stimulated"	136.384	1	136.384	2.595	.135	.191	.313			
	Test-retest Delay	116.117	1	116.117	2.210	.165	.167	.274			

* Type III Sum of Squares

When all sources of covariance were excluded, the repeated measures differences were approaching statistical significance ($F(1,11) = 4.571$, $p = .056$, $\eta^2_{Partial} = .294$, $1 - \beta = .496$). The values were similar to those seen for the original analysis of variance model ($F(1,15) = 6.636$, $p = .076$, $\eta^2_{Partial} = .195$, $1 - \beta = .431$). Excepting the interaction for average BAC ($F = 0.808$, $p = .388$, $\eta^2_{Partial} = .068$, $1 - \beta = .130$), linear interactions with medium to large effect sizes were calculated for participant age ($F = 1.282$, $p = .282$, $\eta^2_{Partial} = .104$, $1 - \beta = .179$), "Stimulated" ($F = 2.595$, $p = .135$, $\eta^2_{Partial} = .191$, $1 - \beta = .313$) and test-retest delay ($F = 2.210$, $p = .165$, $\eta^2_{Partial} = .167$, $1 - \beta = .274$). The findings suggest an absence of influence of average BAC in the model but considerable influence of the covariates in producing the repeated measures differences. The findings of a final repeated measures analysis of covariance model are presented in Table 52 which permits the influence of average BAC in the assessment of the repeated measures.

Table 52

Listening Recall Repeated Measures Analysis of Covariance Models Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			Statistics				Error		
		*SS**	*df*	*Mean Square*	F	p	$\eta^2_{Partial}$	Power (1-β)	*SS**	*df*	*Mean Square*
Listening Recall	Model	201.286	1	201.286	3.893	.072	.245	.442	620.474	12	51.706
	Age	36.901	1	36.901	0.714	.415	.056	.122			
	"Stimulated"	185.205	1	185.205	3.582	.083	.230	.414			
	Test-retest Delay	113.980	1	113.980	2.204	.163	.155	.277			

* Type III Sum of Squares

The model including variance introduced by average BAC, but controlling for the extraneous covariates, had similar statistical values to the other repeated measures analysis of covariance models ($F(1,12) = 3.893$, $p = .072$, $\eta^2_{Partial} = .245$, $1 - \beta = .442$). The effect size was large, and the model approached statistical significance ($p < .08$). Furthermore, large effect sizes were seen for the interactions for the covariates "Stimulated" ($F = 3.582$, $p = .083$, $\eta^2_{Partial} = .230$, $1 - \beta = .414$) and test-retest delay ($F = 2.204$, $p = .163$, $\eta^2_{Partial} = .155$, $1 - \beta = .277$). Unlike the statistics for some of the other subtests, the interaction for participant age within this model was not statistically substantial ($F = 0.714$, $p = .415$, $\eta^2_{Partial} = .056$, $1 - \beta = .122$). The correlational studies considered earlier noted an attenuating influence of participant age on the relationship between average BAC and differences on the Listening Recall subtest, perhaps being associated with its absence of interaction with the difference score within the models. The findings suggest that the Listening Recall subtest performance did differ over the two conditions with a large effect size but no single covariate, including average BAC, appeared to be highly influential in accounting for the differences.

Counting Recall. The improvement in performance under the experimental condition on the Counting Recall subtest ($M_{\text{Difference}} = -6.625$) was statistically significant ($F(1,15) = 5.403$, $p = .035$, $\eta^2_{Partial} = .265$, $1 - \beta = .585$). The statistical values were similar when the influence of average BAC was removed, implying a lack of extraneous influence from this covariate ($F(1,14) = 4.998$, $p = .042$, $\eta^2_{Partial} = .263$, $1 - \beta = .548$). The absence of a statistically large interaction effect suggested an absence of a linear regression model ($F = 0.846$, $p = .373$, $\eta^2_{Partial} = .057$, $1 - \beta = .138$). The interaction effect, and correlation ($r = .239$, $p = .373$), suggest little direct linear influence of average BAC on the repeated measures differences on the Counting Recall subtest. The stability of the *F* statistic, and effect size, coupled with the small interaction effect as a linear model, suggests a lack of influence of average BAC on the differences between the repeated measures of Counting Recall.

Despite the relationship between average BAC and participant age (r = -.581, p = .018), removal of the influence of participant age, as a covariate, behaved differently and resulted in a dramatic drop in the magnitude of the model statistics when comparing the repeated measures of the Counting Recall subtest (F(1,14) = 0.024, p = .879, $\eta^2_{Partial}$ = .002, 1 – β = .052). However, the linear correlation between the Counting Recall subtest differences and participant age was weak (r = -.032, p = .905), also reflected by the absence of a statistically significant interaction effect (F = 0.015, p = .905, $\eta^2_{Partial}$ = .001, 1 – β = .051). Although removal of participant age resulted in a reduction in the statistical magnitude of the repeated measures differences, the lack of linear relationship suggests an indirect influence.

Controlling for the influence of both average BAC and participant age resulted in similar model statistics to that of participant age alone (F(1,13) = 0.612, p = .448, $\eta^2_{Partial}$ = .045, 1 – β = .112). Statistically strong linear models were also not evident within this model for either average BAC in interaction with the Counting Recall subtest repeated measures differences (F = 1.023, p = .330, $\eta^2_{Partial}$ = .073, 1 – β = .155), or for participant age (F = 0.239, p = .633, $\eta^2_{Partial}$ = .018, 1 – β = .074). Although the control for the influence of participant age resulted in the negation of the statistical significance of the repeated measures differences, neither age, nor average BAC, showed sufficient linear association to the repeated measures differences to imply a causative influence. Participant age also did not appear to substantially alter the zero-order relationship between the Counting Recall subtest differences and average BAC (r = .239, p = .373) based on the exclusion of the covariate through calculation of a partial correlation coefficient (r = .270, p = .330) or semi-partial correlation coefficient (r = .270, p = .330). The correlational studies indicate a lack of influence from participant age in the average BAC to Counting Recall subtest differences relationship, suggesting an influence of participant age alone in altering the F statistic of the model. Similar statistics were calculated when "Stimulated" was controlled for rather than participant age.

When the influence of variance introduced by the early assessment measurements of stimulation as the "Stimulated" scale, the repeated measures analysis of covariance for the Counting Recall subtest was not statistically significant and was representative of a substantial drop in the model statistics in comparison to the original analysis of variance (F(1,14) = 0.623, p = .443, $\eta^2_{Partial}$ = .043, 1 – β = .114). Although this finding implies a statistical influence of "Stimulated", a strong linear relationship was not evident (r = .092, p = .735), also reflected in the low statistical values of the interaction (F = 0.119, p = .735, $\eta^2_{Partial}$ = .008, 1 – β = .062).

Control of both average BAC and "Stimulated, within a single repeated measures analysis of covariance model, resulted in the calculation of similar statistics to that of the model controlling for "Stimulated" only ($F(1,13) = 0.254$, $p = .623$, $\eta^2_{Partial} = .019$, $1 - \beta = .075$). In this model, no statistically large interaction statistics were calculated for the covariates average BAC ($F = 0.683$, $p = .423$, $\eta^2_{Partial} = .050$, $1 - \beta = .120$) or "Stimulated" ($F = 0.013$, $p = .910$, $\eta^2_{Partial} = .001$, $1 - \beta = .051$). The absence of linear interaction effects implies the absence of a direct linear effect on the repeated measures differences for the Counting Recall subtest. Furthermore, the covariate "Stimulated" did not substantially alter the association between average BAC and the repeated measures differences on the Counting Recall subtest ($r = .239$, $p = .373$). Control for the influence of "Stimulated" resulted in the calculation of a partial correlation coefficient ($r = .223$, $p = .423$), and semi-partial correlation coefficient ($r = .222$, $p = .423$), which were close in value to the zero-order correlation coefficient ($r = .239$, $p = .373$). The correlational analyses imply the absence of an influence of "Stimulated" on the repeated measures differences to average BAC relationship, despite the association between "Stimulated" and average BAC ($r = .497$, $p = .050$).

A repeated measures analysis of covariance model controlling for the influence of test-retest delay had a large effect size, and a lower probability value than many other models, ($F(1,14) = 3.332$, $p = .089$, $\eta^2_{Partial} = .192$, $1 - \beta = .398$). However, these values do represent a reduction in comparison to the full repeated measures analysis of variance model ($F(1,15) = 5.403$, $p = .035$, $\eta^2_{Partial} = .265$, $1 - \beta = .585$). Furthermore, the correlation coefficient between the repeated measures differences on the Counting Recall subtest and test-retest delay did suggest some tendency towards deteriorations in performance when delays were longer, but was not statistically strong ($r = .203$, $p = .451$). The linear interaction of test-retest delay within the model also illustrates this association which was not substantial ($F = 0.602$, $p = .451$, $\eta^2_{Partial} = .041$, $1 - \beta = .112$).

The repeated measures analysis of variance model inclusive of all sources of variance was statistically significant ($F(1,15) = 5.403$, $p = .035$, $\eta^2_{Partial} = .265$, $1 - \beta = .585$) in statistically classifying the improvements in performance on the Counting Recall subtest ($M_{\text{Difference}} = -6.625$). However, reductions in the model statistics were observed when repeated measures analysis of covariance models were used to separately control for participant age ($F(1,14) = 0.024$, $p = .879$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$), "Stimulated" ($F(1,14) = 0.623$, $p = .443$, $\eta^2_{Partial} = .043$, $1 - \beta = .114$), as well as test-retest delay ($F(1,14) = 3.332$, $p = .089$,

$\eta^2_{Partial}$ = .192, 1 – β = .398). Table 53 shows a model excluding all covariates, including average BAC, to formally assess the differences over the repeated measures.

Table 53

Counting Recall Repeated Measures Analysis of Covariance Models Controlling for Average BAC, Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			Statistics				Error		
		*SS**	*df*	*Mean Square*	F	p	$\eta^2_{Partial}$	Power (1-β)	*SS**	*df*	*Mean Square*
Counting Recall	Model	50.784	1	50.784	0.727	.412	.062	.122	768.602	11	69.873
	BAC	66.614	1	66.614	0.953	.350	.080	.145			
	Age	0.016	1	0.016	0.000	.988	.000	.050			
	"Stimulated"	37.080	1	37.080	0.531	.482	.046	.102			
	Test-retest Delay	134.040	1	134.040	1.918	.193	.148	.244			

* Type III Sum of Squares

The model in Table 53 also shows a substantial reduction in the magnitude of the statistics (F(1,11) = 0.727, p = .412, $\eta^2_{Partial}$ = .062, 1 – β = .122). Small statistical interaction values were calculated for average BAC (F = 0.953, p = .350, $\eta^2_{Partial}$ = .080, 1 – β = .145), participant age (F = 0.000, p = .988, $\eta^2_{Partial}$ = .000, 1 – β = .050) and "Stimulated" (F = 0.531, p = .482, $\eta^2_{Partial}$ = .046, 1 – β = .102). However, the interaction for test-retest delay did have a medium-large effect size (F = 1.918, p = .193, $\eta^2_{Partial}$ = .148, 1 – β = .244). These findings suggested that the covariates were responsible for a substantial portion of variance which led to the statistics found in the original repeated measures analysis of variance model (F(1,15) = 5.403, p = .035, $\eta^2_{Partial}$ = .265, 1 – β = .585). Table 54 assesses the relative importance of including variance from average BAC in these calculations.

Table 54

Counting Recall Repeated Measures Analysis of Covariance Models Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Counting Recall	Model	23.705	1	23.705	0.341	.570	.028	.084	835.216	12	69.601
	Age	12.382	1	12.382	0.178	.681	.015	.068			
	"Stimulated"	68.194	1	68.194	0.980	.342	.075	.149			
	Test-retest Delay	131.160	1	131.160	1.884	.195	.136	.244			

* Type III Sum of Squares

Allowing the inclusion of variance sourced from average BAC, but controlling for the remaining covariates, resulted in a repeated measures analysis of covariance model which was not statistically significant, nor substantially different from any other model controlling for the covariates (F(1,12) = 0.341, p = .570, $\eta^2_{Partial}$ = .028, 1 – β = .084). Furthermore, as seen previously, the within model interaction for test-retest delay had a large effect size (F = 1.884, p = .195, $\eta^2_{Partial}$ = .136, 1 – β = .244) indicating that this covariate may have carried some

responsibility for the original differences observed when other sources of variance are excluded ($F(1,15) = 5.403$, $p = .035$, $\eta^2_{Partial} = .265$, $1 - \beta = .585$). Linear interactions were statistically negligible for participant age ($F = 0.178$, $p = .681$, $\eta^2_{Partial} = .015$, $1 - \beta = .068$) and "Stimulated" ($F = 0.980$, $p = .342$, $\eta^2_{Partial} = .075$, $1 - \beta = .149$). The improvements observed on the Counting Recall subtest ($M_{\text{Difference}} = -6.625$), which were statistically significant ($p < .05$) may have been a product of test-retest delay rather than other covariates or intrinsic changes in performance.

Backwards Digit. Like the other subtests measuring Verbal Working Memory, the Backwards Digit subtest performance improved under the experimental condition ($M_{\text{Difference}} = -6.813$). The repeated measures analysis of variance model approached statistical significance ($F(1,15) = 3.949$, $p = .065$, $\eta^2_{Partial} = .208$, $1 - \beta = .460$). When the influence of average BAC was controlled for, only a minimal decrease in the *F* statistic was evident and the large effect size was retained ($F(1,14) = 3.256$, $p = .093$, $\eta^2_{Partial} = .189$, $1 - \beta = .390$). The repeated measures analysis of covariance model statistics implied a lack of linear influence of average BAC as a covariate. As a linear model, this was illustrated by the absence of a substantial interaction effect ($F = 0.444$, $p = .516$, $\eta^2_{Partial} = .031$, $1 - \beta = .095$) and an insubstantial correlational relationship ($r = .175$, $p = .516$) implying only a slight tendency towards lesser improvements, or deteriorations, in performance under the experimental condition. The findings indicate that controlling for average BAC levels did not substantially alter the statistics of difference in the models. Participant age was correlated statistically significantly with average BAC ($r = -.581$, $p = .018$) and control for this variable resulted in an increase in the model statistics.

Control for the influence of participant age in the assessment of the differences between the repeated measures of Backwards Digit resulted in the model increasing statistical significance ($F(1,14) = 5.403$, $p = .036$, $\eta^2_{Partial} = .278$, $1 - \beta = .581$). In this case, a stronger simple linear association was present ($r = .484$, $p = .057$). The interaction was approaching statistical significance as an interaction in the analysis of covariance model ($F = 4.290$, $p = .057$, $\eta^2_{Partial} = .235$, $1 - \beta = .488$). Although improvements in performance were calculated on average, a tendency towards lesser improvements, or deterioration in performance, with increased age was present.

Combination of the two components as covariates in a repeated measures analysis of covariance model resulted in further increases in the *F* statistics ($F(1,13) = 17.451$, $p = .001$, $\eta^2_{Partial} = .573$, $1 - \beta = .971$). Linear interactions were present within this model for both

average BAC (F = 9.059, p = .010, $\eta^2_{Partial}$ = .411, 1 – β = .794) and participant age (F = 14.932, p = .002, $\eta^2_{Partial}$ = .535, 1 – β = .946). The linear effects implied a stronger influence of participant age than average BAC although both linearly contributed to the repeated measures differences on the Backwards Digit subtest. The average BAC relationship with the Backwards Digit subtest repeated measures differences (r = .175, p = .516) had also been strongly reduced by the influence of participant age. When participant age was controlled for, substantial increases in magnitude, and statistical significance, were calculated utilising a partial correlation coefficient (r = .641, p = .010) and semi-partial correlation coefficient (r = .561, p = .010). Therefore, the influence of participant age clearly reduced the true association between average BAC and repeated measures differences on the Backwards Digit subtest, resulting in reduced statistical values in the repeated measures analysis of variance model inclusive of this influence. The interrelationship between average BAC and participant age (r = .581, p = .018) was influential in assessing the repeated measures differences. The "Stimulated" scale was also correlated with average BAC (r = .497, p = .050) as well as participant age (r = -.517, p = .040).

Exclusion of the influence of subjective congruence with the "Stimulated" items early in the assessment resulted in a dramatic reduction of the F statistic (F(1,14) = 0.012, p = .915, $\eta^2_{Partial}$ = .001, 1 – β = .051) with an absence of a clear linear relationship (F = 0.258, p = .620, $\eta^2_{Partial}$ = .018, 1 – β = .076). Evidently, influence due to variance introduced by "Stimulated" resulted in a magnification of the observed differences. This was likely due to the unexpected negative correlation between the repeated measures differences on the Backwards Digit subtest and "Stimulated" (r = -.134, p = .620) indicating that lower sensations of "Stimulated" were associated with larger improvements in performance. This was converse to that expected based on other findings and the generally positive correlational relationships between average BAC and the various repeated measures difference values.

Control for the influence of both average BAC and "Stimulated" resulted in a repeated measures analysis of covariance model which retained low statistical values (F(1,13) = 0.172, p = .685, $\eta^2_{Partial}$ = .013, 1 – β = .067). The limited linear role of the covariates in this model was illustrated by a weak linear interaction effect for average BAC (F = 1.119, p = .309, $\eta^2_{Partial}$ = .079, 1 – β = .165) and for "Stimulated" (F = 0.937, p = .351, $\eta^2_{Partial}$ = .067, 1 – β = .146). However, correlational studies did suggest that "Stimulated" may have attenuated the expected positive association between average BAC and differences on the Backwards Digit subtest repeated measures. The zero-order correlation coefficient between differences on the

subtest and average BAC (r = .175, p = .516) was fractionally enhanced in a positive direction when the influence of "Stimulated" was excluded through calculation of a partial correlation coefficient (r = .281, p = .309) and semi-partial correlation coefficient (r = .279, p = .309).

Controlling for the influence of test-retest delay, the repeated measures analysis of covariance model for the Backwards Digit subtest was statistically significant (F(1,14) = 5.116, p = .040, $\eta^2_{Partial}$ = .268, 1 – β = .558). The statistics were slightly larger than those of the original repeated measures analysis of variance (F(1,15) = 3.949, p = .065, $\eta^2_{Partial}$ = .208, 1 – β = .460). The correlational analysis showed a moderate positive association between the length of delay associated with tendencies towards deteriorations in performance which was not statistically significant (r = .355, p = .177). The interaction within the model was not statistically significant but a medium effect size was calculated (F = 2.020, p = .177, $\eta^2_{Partial}$ = .126, 1 – β = .263). The findings imply that test-retest delay may have had a moderate influence on the repeated measures model.

In comparison to the normal repeated measures analysis of variance for the Backwards Digit subtest (F(1,15) = 3.949, p = .065, $\eta^2_{Partial}$ = .208, 1 – β = .460), control for the influence of participant age magnified the model statistics (F(1,14) = 5.403, p = .036, $\eta^2_{Partial}$ = .278, 1 – β = .581), as did control for test-retest delay (F(1,14) = 5.116, p = .040, $\eta^2_{Partial}$ = .268, 1 – β = .558). Control for "Stimulated" reduced the magnitude of the model statistics (F(1,14) = 0.012, p = .915, $\eta^2_{Partial}$ = .001, 1 – β = .051). Although the influences were inverse, all the covariates did impact the assessment of the repeated measures differences implying some impact of variance introduced from these sources. Table 55 shows the repeated measures analysis of covariance model controlling for the influence of average BAC, participant age, "Stimulated" and test-retest delay.

Table 55

Backwards Digit Repeated Measures Analysis of Covariance Models Controlling for Average BAC, Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Backwards Digit	Model	525.848	1	525.848	10.034	.009	.477	.822	576.466	11	52.406
	BAC	423.094	1	423.094	8.073	.016	.423	.735			
	Age	466.151	1	466.151	8.895	.012	.447	.775			
	"Stimulated"	9.269	1	9.269	0.177	.682	.016	.067			
	Test-retest Delay	58.892	1	58.892	1.124	.312	.093	.163			

* Type III Sum of Squares

The Backwards Digit repeated measures analysis of covariance model controlling for the influence of all identified covariates, including average BAC, was highly statistically

significant ($F(1,11) = 10.034$, $p = .009$, $\eta^2_{Partial} = .477$, $1 - \beta = .822$). The primary linear influences were sourced from average BAC ($F = 8.073$, $p = .016$, $\eta^2_{Partial} = .423$, $1 - \beta = .735$) and participant age ($F = 8.895$, $p = .012$, $\eta^2_{Partial} = .447$, $1 - \beta = .775$). Despite impacting the model statistics individually, minimal linear influence was introduced by "Stimulated" ($F = 0.177$, $p = .682$, $\eta^2_{Partial} = .016$, $1 - \beta = .067$) or test-retest delay ($F = 1.124$, $p = .312$, $\eta^2_{Partial} = .093$, $1 - \beta = .163$). Given the necessity of the within-person comparisons based on average BAC, Table 56 shows the repeated measures analysis of covariance model allowing the introduction of variance due to alcohol consumption but excluding the extraneous influence of the other covariates.

Table 56

Backwards Digit Repeated Measures Analysis of Covariance Models Controlling for Participant Age, "Stimulated" and Test-retest Delay (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Backwards Digit	Model	305.930	1	305.930	3.673	.079	.234	.422	999.560	12	83.297
	Age	208.580	1	208.580	2.504	.140	.173	.308			
	"Stimulated"	66.412	1	66.412	0.797	.389	.062	.131			
	Test-retest Delay	54.116	1	54.116	0.650	.436	.051	.115			

* Type III Sum of Squares

Following control for the covariates, whilst permitting for variance due to average BAC, the repeated measures analysis of covariance model had a large effect size and approached statistical significance ($F(1,12) = 3.673$, $p = .079$, $\eta^2_{Partial} = .234$, $1 - \beta = .422$). Examination of the within model interaction revealed considerable linear interaction, or impact, from participant age ($F = 2.504$, $p = .140$, $\eta^2_{Partial} = .173$, $1 - \beta = .308$). Interactions were minimal for "Stimulated" ($F = .797$, $p = .389$, $\eta^2_{Partial} = .062$, $1 - \beta = .131$) or test-retest delay ($F = 0.650$, $p = .436$, $\eta^2_{Partial} = .051$, $1 - \beta = .115$). Coupled with the interactions calculated, and the models excluding the influence of individual covariates, the findings indicate that average BAC introduced a considerable source of variance, as did participant age. Control for average BAC substantially reduced the model statistics in circumstances when other covariates were controlled for, suggesting some attenuating influence on the differences from this variable's inclusion.

Visuo-spatial Short-term Memory. The Visuo-spatial Short-term Memory composite consisted of the subtests Dot Matrix, Mazes Memory and Block Recall. Of the differences between the subtests, none differed significantly across the repeated measures ($p > .05$). Test-retest delay, as a measurement of potential practice effects, did not seem to have a substantial relationship with the difference scores (see "Models and Interactions of Additional Covariates"

in this Chapter). The RPM, despite also being a visuo-spatial task, was also not closely associated with any of the Visuo-spatial Short-term Memory subtests (see "Models and Interactions of Additional Covariates" in this Chapter). Nonetheless, as previously discussed, these covariates were included in the models. For the RPM, the inclusion was based on the original correlations to the baseline AWMA scores. Participant age was included in the analyses of covariance based on its association with the key covariate, average BAC (r = -.581, p = .018), as was "Stimulated" (r = .497, p = .050) which was also correlated with participant age (r = -.517, p = .040), suggesting an interactive influence. The following pages show tabular records of the repeated measures analysis of covariance models considering these covariates. Table 57 shows the analysis of covariance model controlling for average BAC whilst Table 58 and Table 59 show the models controlling for participant age and both average BAC and participant age respectively.

None of the Visuo-spatial Short-term Memory subtests differed statistically significantly when average BAC was controlled for. Alterations in the F statistics in comparison to the original analysis of variance models were evident, but no statistically significant interactions were calculated. Control for the variable "Age" resulted in similar statistics, shown in Table 58, as did control for average BAC and participant age in tandem, the models of which are shown in Table 59.

Control for participant age, singly and in combination with average BAC, did result in some changes to the model statistics in comparison to the full repeated measures analysis of variance model. Control of the "Stimulated" variable in the comparison of the repeated measures means also resulted in changes in the F statistic in comparison to the original model. The analysis of covariance models are shown in Table 60 whilst Table 61 show the repeated measures analysis of covariance models controlling for both average BAC and "Stimulated" to account for the correlational association between the two covariates.

Table 57

Visuo-spatial Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	2.810	1	2.810	.041	.843	.003	.054	29.645	1	29.645	.430	.523	.030	.094	965.355	14	68.954
Mazes Memory	187.081	1	187.081	1.303	.273	.085	.186	3.155	1	3.155	.022	.884	.002	.052	2010.845	14	143.632
Block Recall	20.344	1	20.344	.487	.497	.034	.100	33.326	1	33.326	.798	.387	.054	.133	584.549	14	41.754

* Type III Sum of Squares

Table 58

Visuo-spatial Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Participant Age (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	26.003	1	26.003	0.372	.552	.026	.088	16.733	1	16.733	0.239	.632	.017	.074	978.267	14	69.876
Mazes Memory	4.869	1	4.869	0.034	.857	.002	.053	0.002	1	0.002	0.000	.997	.000	.050	2013.998	14	143.857
Block Recall	27.402	1	27.402	0.650	.434	.044	.117	27.361	1	27.361	0.649	.434	.044	.117	590.514	14	42.180

* Type III Sum of Squares

Table 59

Visuo-spatial Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and Participant Age (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	Model	1.851	1	1.851	0.025	.877	.002	.052	964.052	13	74.158
	BAC	14.215	1	14.215	0.192	.669	.015	.069			
	Age	1.303	1	1.303	0.018	.897	.001	.052			
Mazes Memory	Model	9.459	1	9.459	0.061	.808	.005	.056	2009.380	13	154.568
	BAC	4.618	1	4.618	0.030	.865	.002	.053			
	Age	1.465	1	1.465	0.009	.924	.001	.051			
Block Recall	Model	122.343	1	122.343	3.360	.090	.205	.397	473.422	13	36.417
	BAC	117.092	1	117.092	3.215	.096	.198	.383			
	Age	111.128	1	111.128	3.052	.104	.190	.366			

* Type III Sum of Squares

Table 60

Visuo-spatial Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for "Stimulated" (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	61.082	1	61.082	0.894	.360	.060	.143	38.965	1	38.965	0.571	.463	.039	.109	956.035	14	68.288
Mazes Memory	3.543	1	3.543	0.025	.877	.002	.053	32.266	1	32.266	0.228	.640	.016	.073	1981.734	14	141.552
Block Recall	1.762	1	1.762	0.040	.844	.003	.054	2.036	1	2.036	0.046	.833	.003	.055	615.839	14	43.988

* Type III Sum of Squares

Table 61

Visuo-spatial Short-term Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and "Stimulated" (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	Model	107.305	1	107.305	1.624	.225	.111	.219	859.093	13	66.084
	BAC	96.942	1	96.942	1.467	.247	.101	.202			
	"Stimulated"	106.262	1	106.262	1.608	.227	.110	.217			
Mazes Memory	Model	11.241	1	11.241	0.075	.789	.006	.057	1953.670	13	150.282
	BAC	28.064	1	28.064	0.187	.673	.014	.069			
	"Stimulated"	57.175	1	57.175	0.380	.548	.028	.088			
Block Recall	Model	11.961	1	11.961	0.278	.607	.021	.078	560.066	13	43.082
	BAC	55.772	1	55.772	1.295	.276	.091	.184			
	"Stimulated"	24.483	1	24.483	0.568	.464	.042	.108			

* Type III Sum of Squares

Control for the "Stimulated" scale also resulted in some changes in the *F* statistics, and effect sizes, suggesting influence of the scale in association with average BAC. The next sections discuss the Visuo-spatial Short-term Memory subtests in detail.

Dot Matrix. Performance on the Dot Matrix subtest improved during the experimental assessment ($M_{\text{Difference}}$ = -3.000) but the repeated measures analysis of variance was not statistically significant ($F(1,15) = 1.085$, $p = .314$, $\eta^2_{Partial} = .067$, $1 - \beta = .164$). When average BAC was controlled for, the magnitude of the *F* statistic reduced ($F(1,14) = 0.041$, $p = .843$, $\eta^2_{Partial} = .003$, $1 - \beta = .054$) a weak interaction was calculated ($F = 0.430$, $p = .523$, $\eta^2_{Partial} = .030$, $1 - \beta = .094$). A slight negative correlation represented the interaction, suggesting a slight tendency for improvements in performance to be associated with higher average BAC readings ($r = -.173$, $p = .523$). The correlational relationship was inverse to that seen for the Verbal Short-term Memory, and Verbal Working Memory, subtests. Generally, deteriorations in performance were noted, although small tendencies towards zero change may have been evident at higher average BAC levels.

When participant age was controlled for in the comparison of the repeated measures on the Dot Matrix subtest, the model was not statistically significant but did show a reduction in the *F* statistic ($F(1,14) = 0.372$, $p = .552$, $\eta^2_{Partial} = .026$, $1 - \beta = .088$) but no strong interaction was calculated ($F = 0.239$, $p = .632$, $\eta^2_{Partial} = .017$, $1 - \beta = .074$). The differences on the Dot Matrix subtest were not strongly correlated with participant age ($r = .130$, $p = .632$). The exclusion of these influences did result in changes in the *F* statistic of the analysis of variance model suggesting some influence.

Control for both average BAC and participant age in a single model did not result in a statistically significant model and the magnitude of the *F* statistic reduced in comparison to that of the individual models ($F(1,13) = 0.025$, $p = .877$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$). In the analysis of covariance model controlling for both average BAC and participant age, no statistically powerful linear interaction was present for average BAC ($F = 0.192$, $p = .669$, $\eta^2_{Partial} = .015$, $1 - \beta = .069$) or for participant age ($F = 0.018$, $p = .897$, $\eta^2_{Partial} = .001$, $1 - \beta = .052$). Correlational analyses showed a weak, negative, zero-order correlation coefficient between average BAC and the Dot Matrix subtest repeated measures differences ($r = -.173$, $p = .523$). When the influence of participant age was excluded from variance in both variables, the absolute magnitude of the partial correlation coefficient was slightly lower ($r = -.121$, $p = .669$). The same applied to the semi-partial correlation coefficient ($r = -.120$, $p = .669$). The findings suggest that although participant age was strongly related to average BAC readings ($r = -.581$, $p = .018$), average BAC, with or without the influence of participant ages, was not strongly related to the differences observed between the repeated measures of the Dot Matrix subtest. Similar findings were calculated for "Stimulated" which was correlated with both average BAC ($r = .497$, $p = .050$) and participant age ($r = -.517$, $p = .040$).

Control for the influence of the "Stimulated" scale from the comparison of means on the Dot Matrix subtest slightly reduced the value of the *F* statistic in the analysis of covariance model which was not statistically significant ($F(1,14) = 0.894$, $p = .360$, $\eta^2_{Partial} = .060$, $1 - \beta = .143$). The *F* statistic value was considerably closer to that of the analysis of variance model ($F(1,15) = 1.085$, $p = .314$, $\eta^2_{Partial} = .067$, $1 - \beta = .164$) suggesting that "Stimulated" may not have been particularly influential in modelling the observed differences. No simple linear relationship was apparent between "Stimulated" and differences on the Dot Matrix subtest ($r = .198$, $p = .463$) which is reflected in the absence of a statistically significant interaction within the repeated measures analysis of covariance model ($F = 0.571$, $p = .463$, $\eta^2_{Partial} = .039$, $1 - \beta = .109$). General congruence with the "Stimulated" terms during the early portions of the assessment was noted as being slightly associated with tendencies towards deterioration in performance under the experimental condition ($r = .198$, $p = .463$). Therefore, average BAC and "Stimulated" were both somewhat associated with tendencies towards deteriorations in performance, or lesser improvements, as well as being correlated with one another ($r = .497$, $p = .050$).

An analysis of covariance model holding both covariates constant resulted in a slight increase in the *F* statistic ($F(1,13) = 1.624$, $p = .225$, $\eta^2_{Partial} = .111$, $1 - \beta = .219$) with moderate

interactions for average BAC (F = 1.467, p = .247, $\eta^2_{Partial}$ = .101, 1 – β = .202) and "Stimulated" (F = 1.608, p = .227, $\eta^2_{Partial}$ = .110, 1 – β = .217). Although the interactions imply some linear relationship within the model, the changes in the F statistic, and effect size, were not particularly substantial. The presence of some linear relationship suggests the possibility of some influence of "Stimulated" on the relationship between average BAC and the repeated measures differences on the Dot Matrix subtest. The zero-order correlation coefficient between average BAC and differences on the Dot Matrix subtest (r = -.173, p = .523) was substantially increased in absolute magnitude when "Stimulated" was controlled for (r = -.318, p = .247). The semi-partial correlation coefficient was also similar (r = -.312, p = .247) indicating the association between the covariate, "Stimulated", being confined to average BAC exclusive of the Dot Matrix difference values. The findings suggest that "Stimulated" may have had a confounding influence on the repeated measures differences when attempts were made to control for average BAC, resulting in an inconclusive model.

The model comparing the repeated measures of the Dot Matrix values, controlling for test-retest delay period, was not statistically significant (F(1,14) = 1.098, p = .312, $\eta^2_{Partial}$ = .073, 1 – β = .165). Statistical values were similar to those calculated for the analysis of variance model inclusive of the influence of test-retest delay (F(1,15) = 1.085, p = .314, $\eta^2_{Partial}$ = .067, 1 – β = .164). In the previous section, the negative correlation coefficient (r = -.447, p = .083) was discussed, implying a tendency towards improvement in scores when delays were longer, the opposite of expected should practice effects be present. Resultantly, an interaction effect of some statistical strength was present (F = 3.492, p = .083, $\eta^2_{Partial}$ = .200, 1 – β = .413).

The Dot Matrix subtest's baseline and experimental scores did not differ significantly when the influence of the RPM was removed (F(1,14) = 0.000, p = .994, $\eta^2_{Partial}$ = .000, 1 – β = .050) and no statistically significant interaction effect was present (F = 0.016, p = .900, $\eta^2_{Partial}$ = .001, 1 – β = .052). The original repeated measures analysis of variance model's F values were considerably stronger (F(1,15) = 1.085, p = .314, $\eta^2_{Partial}$ = .067, 1 – β = .164), indicating some form of attenuating influence of the RPM values. The correlation coefficient between the RPM scores and the Dot Matrix difference score was weak (r = -.034, p = .900), reflecting the absence of an interaction effect.

Despite the lack of association and interaction between the covariate and the Dot Matrix subtest improvement in score ($M_{\text{Difference}}$ = -3.000), the removal of the RPM values did alter the statistical significance of the model by reducing the F value (F(1,14) = 0.000, p = .994, $\eta^2_{Partial}$ = .000, 1 – β = .050) in comparison to the original repeated measures analysis of variance

model ($F(1,15) = 1.085$, $p = .314$, $\eta^2_{Partial} = .067$, $1 - \beta = .164$). The same reduction was observed when average BAC was controlled for ($F(1,14) = 0.041$, $p = .843$, $\eta^2_{Partial} = .003$, $1 - \beta = .054$). A reduction in the model statistics was also seen when participant age was controlled for ($F(1,14) = 0.372$, $p = .552$, $\eta^2_{Partial} = .026$, $1 - \beta = .088$). However, no substantial changes were noted when controlling for "Stimulated" ($F(1,14) = 1.098$, $p = .312$, $\eta^2_{Partial} = .073$, $1 - \beta = .165$) and test-retest delay ($F(1,14) = 1.098$, $p = .312$, $\eta^2_{Partial} = .073$, $1 - \beta = .165$). Table 62 shows a repeated measures analysis of covariance controlling for the key covariate, average BAC, and all other covariates.

Table 62

Dot Matrix Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	Model	88.775	1	88.775	2.038	.184	.169	.253	435.507	10	43.551
	BAC	108.670	1	108.670	2.495	.145	.200	.298			
	Age	64.098	1	64.098	1.472	.253	.128	.196			
	"Stimulated"	49.367	1	49.367	1.134	.312	.102	.162			
	Test-retest Delay	110.986	1	110.986	2.548	.141	.203	.304			
	RPM	9.639	1	9.639	0.221	.648	.022	.071			

* Type III Sum of Squares

Control for the influence of all covariates resulted in an increase in the repeated measures model statistics ($F(1,10) = 2.038$, $p = .184$, $\eta^2_{Partial} = .169$, $1 - \beta = .253$). Despite the lack of statistical significance, a large effect size was present ($\eta^2_{Partial} = .169$). Further examination reveals that the primary attenuating effects, based on interaction within the model, were sourced from average BAC ($F = 2.495$, $p = .145$, $\eta^2_{Partial} = .200$, $1 - \beta = .298$) and test-retest delay ($F = 2.548$, $p = .141$, $\eta^2_{Partial} = .203$, $1 - \beta = .304$). Medium effect sizes of the interaction were present for participant age ($F = 1.472$, $p = .253$, $\eta^2_{Partial} = .128$, $1 - \beta = .196$) and "Stimulated" ($F = 1.134$, $p = .312$, $\eta^2_{Partial} = .102$, $1 - \beta = .162$). However, the linear influence of the RPM was minimal ($F = 0.221$, $p = .648$, $\eta^2_{Partial} = .022$, $1 - \beta = .071$). The findings suggest substantial attenuating sources of influence from the covariates. Table 63 shows the repeated measures analysis of covariance model permitting influence from average BAC but controlling for the influence of all other covariates.

Table 63

Dot Matrix Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Dot Matrix	Model	38.927	1	38.927	0.787	.394	.067	.128	544.177	11	49.471
	Age	15.885	1	15.885	0.321	.582	.028	.081			
	"Stimulated"	92.231	1	92.231	1.864	.199	.145	.239			
	Test-retest Delay	118.857	1	118.857	2.403	.149	.179	.294			
	RPM	24.275	1	24.275	0.491	.498	.043	.098			

* Type III Sum of Squares

The repeated measures analysis of covariance model excluding the influence of the covariates except BAC showed a reduction in the *F* statistic and a small effect size ($F(1,11) = 0.787$, $p = .394$, $\eta^2_{Partial} = .067$, $1 - \beta = .128$). A substantial linear interaction was still observed for test-retest delay ($F = 2.403$, $p = .149$, $\eta^2_{Partial} = .179$, $1 - \beta = .294$) and "Stimulated" ($F = 1.864$, $p = .199$, $\eta^2_{Partial} = .145$, $1 - \beta = .239$). These statistics were not statistically significant, but the effect sizes were large. Little linear interaction was observed for participant age ($F = 0.321$, $p = .582$, $\eta^2_{Partial} = .028$, $1 - \beta = .081$) or the RPM ($F = 0.491$, $p = .498$, $\eta^2_{Partial} = .043$, $1 - \beta = .098$). The findings imply that the statistics of difference of the repeated measures improvement in performance over the two sessions ($M_{\text{Difference}} = -3.000$) was substantially attenuated by the inclusion of variance sourced from average BAC. The covariates appeared to operate in tandem and were interrelated in some manner, as suggested by changes in relative interactions dependent upon the model structure.

Mazes Memory. Performance on the Mazes Memory subtest deteriorated considerably under the experimental condition in comparison to the baseline assessment ($M_{\text{Difference}} = 6.500$). The difference was not statistically significant, but the calculated effect size was medium in magnitude ($F(1,15) = 2.517$, $p = .133$, $\eta^2_{Partial} = .144$, $1 - \beta = .318$). The value of the *F* statistic decreased substantially when average BAC was controlled for in a repeated measures analysis of covariance model ($F(1,14) = 1.303$, $p = .273$, $\eta^2_{Partial} = .085$, $1 - \beta = .186$), suggesting a magnifying effect of average BAC in comparing the repeated measures scores. However, no substantial interaction was present suggesting the absence of a simple linear relationship to the differences ($F = 0.022$, $p = .884$, $\eta^2_{Partial} = .002$, $1 - \beta = .052$). Average BAC was not statistically significantly correlated with differences over the repeated measures of Mazes Memory ($r = -.040$, $p = .884$). However, the correlation of average BAC to participant age ($r = -.581$, $p = .018$) may have confounded the linear relationship or caused a confounding relationship due to the negative association.

After controlling for the influence of participant age, differences over the repeated measures were not statistically significant and a substantial reduction in the *F* statistic was calculated ($F(1,14) = 0.034$, $p = .857$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$). The findings imply that the inclusion of variance from participant age, like that for average BAC, magnified the statistical values of the deterioration in performance under the experimental condition. No simple linear interaction was present between participant age and differences on the Mazes Memory subtest ($r = .001$, $p = .997$), reflected in the absence of an interaction within the model ($F = 0.000$, $p = .997$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$).

Removal of the influence of average BAC and participant age in tandem resulted in an analysis of covariance model with similar statistical values to that of the models controlling for the covariates separately ($F(1,13) = 0.061$, $p = .808$, $\eta^2_{Partial} = .005$, $1 - \beta = .056$). No interaction of statistical importance was present for either average BAC ($F = 0.030$, $p = .865$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$) or participant age ($F = 0.009$, $p = .924$, $\eta^2_{Partial} = .001$, $1 - \beta = .051$). The reduction in the *F* statistic after controlling for average BAC and participant age implied some magnifying influence of the covariates on the statistical magnitude of the differences between the repeated measures within the model. Further exploration of the statistical relationship through the exclusion of participant age from the correlation between average BAC and differences on the Mazes Memory subtest ($r = -.040$, $p = .884$) did not result in an increase in the strength of the relationship through removal of the influence of participant age by calculation of a partial correlation coefficient ($r = -.048$, $p = .865$) or semi-partial correlation coefficient ($r = -.048$, $p = .865$). Although both average BAC and participant age introduced sources of variance in the comparison of the repeated measures of the Mazes Memory subtest, participant age did not attenuate, or magnify, the relationship between average BAC and the repeated measures differences on the Mazes Memory subtest. Similar findings were obtained when "Stimulated" was examined as a known correlate of both average BAC ($r = .497$, $p = .050$) and participant age ($r = -.517$, $p = .040$).

Comparisons of the repeated measures, controlling for the influence of "Stimulated", produced a model showing a reduction of the *F* statistic, and effect size, ($F(1,14) = 0.025$, $p = .877$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$) in comparison to the analysis of variance model inclusive of this influence ($F(1,15) = 2.517$, $p = .133$, $\eta^2_{Partial} = .144$, $1 - \beta = .318$). No simple linear relationship was present between differences on the Mazes Memory subtest and "Stimulated" ($r = .127$, $p = .640$) although the correlation coefficient was considerably stronger than that for average BAC ($r = -.040$, $p = .884$), or participant age ($r = .001$, $p = .997$). The absence of a

strong linear relationship as an interaction within the repeated measures analysis of covariance model was also calculated (F = 0.228, p = .640, $\eta^2_{Partial}$ = .016, 1 – β = .073).

A repeated measures analysis of covariance model excluding the influence of both average BAC and "Stimulated" had statistics of similar values (F(1,13) = 0.075, p = .789, $\eta^2_{Partial}$ = .006, 1 – β = .057) without substantial interactions for either average BAC (F = 0.187, p = .673, $\eta^2_{Partial}$ = .014, 1 – β = .69), or "Stimulated" (F = 0.380, p = .548, $\eta^2_{Partial}$ = .028, 1 – β = .088). The zero-order correlation coefficient between average BAC and differences on the Mazes Memory subtest (r = -.040, p = .884) did increase in absolute magnitude when the influence of "Stimulated" was removed using a partial correlation coefficient (r = -.119, p = .673) and semi-partial correlation coefficient (r = -.118, p = .673). The increase in magnitude in the negative direction implies a stronger association between larger average BAC readings and improvements in performance than observed when the influence of "Stimulated" was included. The direction of this relationship implied a slightly stronger tendency towards improvements in performance at higher BAC levels.

Control for test-retest delay in the repeated measures comparison of the Mazes Memory subtest resulted in a repeated measures analysis of covariance model which had a small effect size and was not statistically significant, representing a considerable reduction in statistics in comparison to the analysis of variance model (F(1,14) = 0.224, p = .643, $\eta^2_{Partial}$ = .016, 1 – β = .073). Furthermore, the correlation between the covariate and the repeated measures differences was tending towards zero (r = .093, p = .732), resulting in interaction statistics which were minimal in magnitude (F = 0.122, p = .732, $\eta^2_{Partial}$ = .009, 1 – β = .062).

The original analysis of variance model for the Mazes Memory subtest was not statistically significant, although the moderate effect size was noteworthy (F(1,15) = 2.517, p = .133, $\eta^2_{Partial}$ = .144, 1 – β = .318). However, the statistical values for the deterioration in performance under the experimental condition ($M_{\text{Difference}}$ = 6.500) were of less statistical significance when the influence of the RPM was excluded (F(1,14) = 0.032, p = .860, $\eta^2_{Partial}$ = .002, 1 – β = .053). In addition to the substantial reduction in the F value, no statistically significant correlation was present between the difference and the RPM values (r = .000, p = .999) and no statistically significant interaction effect model for the RPM on the repeated measures analysis (F = 0.000, p = .999, $\eta^2_{Partial}$ = .000, 1 – β = .050) was present.

For the Mazes Memory subtest, the repeated measures analysis of variance model statistics (F(1,15) = 2.517, p = .133, $\eta^2_{Partial}$ = .144, 1 – β = .318) were substantially reduced by separate control for the covariates participant age (F(1,14) = 0.034, p = .857, $\eta^2_{Partial}$ = .002,

1 – β = .053), "Stimulated" (F(1,14) = 0.025, p = .877, $\eta^2_{Partial}$ = .002, 1 – β = .053), test-retest delay (F(1,14) = 0.224, p = .643, $\eta^2_{Partial}$ = .016, 1 – β = .073) and the RPM (F(1,14) = 0.032, p = .860, $\eta^2_{Partial}$ = .002, 1 – β = .053). Although the interactions did not suggest specific linear relationships, the covariates did appear to impact the statistical comparisons of the repeated measures reflecting the deterioration in performance under the experimental condition ($M_{\text{Difference}}$ = 6.500). Table 64 shows the repeated measures analysis of covariance model controlling for all covariates, including average BAC.

Table 64

Mazes Memory Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Mazes Memory	Model	4.863	1	4.863	0.026	.875	.003	.052	1852.355	10	185.235
	BAC	18.317	1	18.317	0.099	.760	.010	.059			
	Age	4.257	1	4.257	0.023	.883	.002	.052			
	"Stimulated"	128.904	1	128.904	0.696	.424	.065	.118			
	Test-retest Delay	98.121	1	98.121	0.530	.483	.050	.101			
	RPM	2.991	1	2.991	0.016	.901	.002	.052			

* Type III Sum of Squares

The repeated measures analysis of covariance model excluding the influence of all covariates, including average BAC, was not statistically significant (F(1,10) = 0.026, p = .875, $\eta^2_{Partial}$ = .003, 1 – β = .052) and the model statistics were substantially lower than those in the original model (F(1,15) = 2.517, p = .133, $\eta^2_{Partial}$, = .144, 1 – β = .318). The linear interactions were not large for any of the covariates. Small effect sizes were observed for the interactions for average BAC (F = 0.099, p = .760, $\eta^2_{Partial}$ = .010, 1 – β = .059), participant age (F = 0.023, p = .883, $\eta^2_{Partial}$ = .002, 1 – β = .052), "Stimulated" (F = 0.696, p = .424, $\eta^2_{Partial}$ = .065, 1 – β = .118), test-retest delay (F = 0.530, p = .483, $\eta^2_{Partial}$ = .050, 1 – β = .101) and the RPM (F = 0.016, p = .901, $\eta^2_{Partial}$ = .002, 1 – β = .052). Resultantly, it appears that the exclusion of all covariates resulted in reduction of the statistical magnitude of the repeated measures differences. Table 65 shows the results of a model excluding the influence of the extraneous covariates but including the influence of average BAC as a potential cause of difference over the repeated measures.

Table 65

Mazes Memory Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Mazes Memory	Model	15.209	1	15.209	0.089	.770	.008	.059	1870.672	11	170.061
	Age	0.082	1	0.082	0.000	.983	.000	.050			
	"Stimulated"	113.768	1	113.768	0.669	.431	.057	.116			
	Test-retest Delay	95.324	1	95.324	0.561	.470	.048	.105			
	RPM	1.050	1	1.050	0.006	.939	.001	.051			

* Type III Sum of Squares

Permitting the inclusion of variance introduced by average BAC did not substantially alter the model statistics when all other covariates were controlled for in the Mazes Memory subtest ($F(1,11) = 0.089$, $p = .770$, $\eta^2_{Partial} = .008$, $1 - \beta = .059$). The linear interactions were small for participant age ($F = 0.000$, $p = .983$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$), "Stimulated" ($F = 0.669$, $p = .431$, $\eta^2_{Partial} = .057$, $1 - \beta = .116$), test-retest delay ($F = 0.561$, $p = .470$, $\eta^2_{Partial} = .048$, $1 - \beta = .105$) and the RPM ($F = 0.006$, $p = .939$, $\eta^2_{Partial} = .001$, $1 - \beta = .051$). These model statistics were substantially smaller than those of the full repeated measures analysis of variance model ($F(1,15) = 2.517$, $p = .133$, $\eta^2_{Partial}$, $= .144$, $1 - \beta = .318$). The findings imply some impact of the covariates resulting in magnified model statistics when all these sources of covariance were included.

Block Recall. Differences on the Block Recall subtest over the repeated measures were not statistically significant ($F(1,15) = 0.003$, $p = .957$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). The statistical magnitude of the improvement in performance under the experimental condition ($M_{\text{Difference}} = -0.125$) was slightly statistically attenuated by average BAC as evidenced by a slight increase in the *F* statistic when average BAC was controlled for in the repeated measures analysis of covariance model ($F(1,14) = 0.487$, $p = .497$, $\eta^2_{Partial} = .034$, $1 - \beta = .100$). However, this increase was insubstantial and the linear interaction of average BAC within the model was not substantial ($F = 0.798$, $p = .387$, $\eta^2_{Partial} = .054$, $1 - \beta = .133$). The correlation between differences on the repeated measures of Block Recall and average BAC was not statistically significant ($r = .232$, $p = .387$) but did show a slight tendency for participants with higher average BAC readings to show reduced performance under the experimental condition. The strong association between average BAC and the other covariate identified for inclusion, namely, participant age ($r = -.581$, $p = .018$) resulted in a similar correlation coefficient and model statistics also suggesting a lack of influence from this source of variance.

Exclusion of the influence of participant age from the repeated measures comparisons for the Block Recall subtest produced similar statistics to those for the analysis of variance model and the analysis of covariance model controlling for the influence of average BAC ($F(1,14) = 0.650$, $p = .434$, $\eta^2_{Partial} = .044$, $1 - \beta = .117$). This finding implies that the influence of participant age played little role in the differences over the repeated measures. Furthermore, no large interaction was present for participant age ($F = 0.649$, $p = .434$, $\eta^2_{Partial} = .044$, $1 - \beta = .117$). The positive linear correlation coefficient was calculated between participant age and differences on the Block Recall subtest ($r = .210$, $p = .434$) implying a tendency for older participants to show reduced performance under the experimental condition despite their tendency towards lower average BAC readings ($r = -.581$, $p = .018$).

The inverse associations, in parallel, appear confounding and, resultantly, when the influence of both average BAC and participant ages were accounted for, the analysis of covariance model statistics increased substantially ($F(1,13) = 3.360$, $p = .090$, $\eta^2_{Partial} = .205$, $1 - \beta = .397$). Removal of the inverse linear relationship within the repeated measures analysis of covariance model accounting for average BAC along with participant age resulted in clearer linear interactions for the average BAC component ($F = 3.215$, $p = .096$, $\eta^2_{Partial} = .198$, $1 - \beta = .383$) and the participant age component ($F = 3.052$, $p = .104$, $\eta^2_{Partial} = .190$, $1 - \beta = .366$). Exploration of changes to the correlation coefficient between differences on the Block Recall subtest and average BAC ($r = .232$, $p = .387$), accounting for participant age in a partial correlation coefficient ($r = .445$, $p = .096$), and semi-partial correlation coefficient ($r = .435$, $p = .096$), showed consistency between the two coefficients and a substantial increase in the relationship. This finding implies some positive association between average BAC and the repeated measures differences on the Block Recall subtest which was attenuated by the influence of participant age. “Stimulated” was also correlated with both average BAC ($r = .497$, $p = .050$) and participant age ($r = -.517$, $p = .040$). However, sources of variance from “Stimulated” were not as influential.

Removal of the influence of “Stimulated” from the statistical comparison of the repeated measures differences on the Block Recall subtest did not greatly impact the *F* statistic, or effect size, ($F(1,14) = 0.040$, $p = .844$, $\eta^2_{Partial} = .003$, $1 - \beta = .054$). Furthermore, the linear interaction within the model was insubstantial ($F = 0.046$, $p = .833$, $\eta^2_{Partial} = .003$, $1 - \beta = .055$). The interaction was also illustrated in the weak correlation coefficient between the repeated measures differences on the Block Recall subtest and “Stimulated” ($r = -.057$, $p = .833$). The findings show medium to high congruence with feelings of being “Stimulated” but

a lack of clear association with deteriorations, or improvements, in performance under the experimental condition.

When both average BAC and "Stimulated" were controlled for, a similar *F* statistic, and effect size, was calculated ($F(1,13) = 0.278$, $p = .607$, $\eta^2_{Partial} = .021$, $1 - \beta = .078$). The interaction effect for "Stimulated" was not substantial ($F = 0.568$, $p = .464$, $\eta^2_{Partial} = .042$, $1 - \beta = .108$) but that for average BAC increased in comparison to the other models ($F = 1.295$, $p = .276$, $\eta^2_{Partial} = .091$, $1 - \beta = .184$) may be in response to the correlation between the two covariates. These interactions were also illustrated in changes to the zero-order correlation between differences on the Block Recall subtest and average BAC ($r = .232$, $p = .287$). Exclusion of the influence of "Stimulated" from both variables in this relationship as a partial correlation coefficient resulted in some increase in absolute magnitude when a partial correlation coefficient was calculated ($r = .301$, $p = .276$). The magnitude of the semi-partial correlation coefficient ($r = .300$, $p = .276$) was consistent with that of the partial correlation coefficient. The findings imply a small influence of "Stimulated" in reducing the relationship between average BAC and differences on the Block Recall subtest.

Controlling for test-retest delay as a covariate in the repeated measures analysis for the Block Recall subtest resulted in a model which had very small statistical values ($F(1,14) = 0.013$, $p = .912$, $\eta^2_{Partial} = .001$, $1 - \beta = .051$). A weak linear interaction between the test-retest delay covariate and differences on the Block Recall subtest ($F = 0.026$, $p = .875$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$). The correlation coefficient ($r = -.043$, $p = .875$) suggested a lack of influence of test-retest delay on the Block Recall subtest differences. It was apparent that the test-retest delay covariate did not substantially influence the repeated measures analysis of variance model which also had small statistical values ($F(1,15) = 0.003$, $p = .957$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$).

The Block Recall subtest repeated measures differences were not statistically significant when the influence of the RPM raw scores was accounted for ($F(1,14) = 0.432$, $p = .522$, $\eta^2_{Partial} = .030$, $1 - \beta = .094$). However, the analysis of variance model inclusive of this covariate had a lower *F* value and associated statistics ($F(1,15) = 0.003$, $p = .957$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). No statistically significant interaction effect ($F = 0.429$, $p = .523$, $\eta^2_{Partial} = .030$, $1 - \beta = .094$), or correlation coefficient ($r = .172$, $p = .523$), was present although the values were somewhat larger than those seen for the other covariates. The lack of interaction suggests that the change in the value of the statistics may have been attributable to some other factor.

The models controlling for the covariates on the Block Recall subtest had substantially different *F* statistics and effect sizes in comparison to the original model ($F(1,15) = 0.003$, $p = .957$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). The mean difference on the Block Recall subtest showed a fractional improvement under the experimental condition ($M_{Difference} = -0.125$). Control, separately, for covariates resulted in no substantial changes to the *F* statistic when controlling for average BAC ($F(1,14) = 0.798$, $p = .387$, $\eta^2_{Partial} = .054$, $1 - \beta = .133$), participant age ($F(1,14) = 0.649$, $p = .434$, $\eta^2_{Partial} = .044$, $1 - \beta = .117$), "Stimulated" ($F(1,14) = 0.046$, $p = .833$, $\eta^2_{Partial} = .003$, $1 - \beta = .055$), test-retest delay ($F(1,14) = 0.026$, $p = .875$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$) or the RPM ($F(1,14) = 0.429$, $p = .523$, $\eta^2_{Partial} = .030$, $1 - \beta = .094$). However, some cumulative effect of the covariates was observed.

The repeated measures analysis of covariance model for all covariates, including average BAC, showed substantial increase in the *F* statistic without achieving statistical significance but with a large effect size ($F(1,10) = 2.388$, $p = .153$, $\eta^2_{Partial} = .193$, $1 - \beta = .288$). The model statistics are shown in Table 66.

Table 66

Block Recall Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Block Recall	Model	94.281	1	94.281	2.388	.153	.193	.288	394.888	10	39.489
	BAC	140.489	1	140.489	3.558	.089	.262	.400			
	Age	127.421	1	127.421	3.227	.103	.244	.369			
	"Stimulated"	10.985	1	10.985	0.278	.609	.027	.077			
	Test-retest Delay	43.564	1	43.564	1.103	.318	.099	.159			
	RPM	54.282	1	54.282	1.375	.268	.121	.186			

* Type III Sum of Squares

Most influence appeared due to linear interactions for average BAC ($F = 3.558$, $p = .089$, $\eta^2_{Partial} = .262$, $1 - \beta = .400$) and participant age ($F = 3.227$, $p = .103$, $\eta^2_{Partial} = .244$, $1 - \beta = .369$). Lesser interaction values were calculated for test-retest delay ($F = 1.103$, $p = .318$, $\eta^2_{Partial} = .099$, $1 - \beta = .159$) and the RPM ($F = 1.375$, $p = .268$, $\eta^2_{Partial} = .121$, $1 - \beta = .186$). Low values for the interaction were observed for "Stimulated" ($F = 0.278$, $p = .609$, $\eta^2_{Partial} = .027$, $1 - \beta = .077$). The alteration in model statistics appeared to be due to linear interactions from average BAC and participant age, accompanied by some influence from the RPM for which the interaction had a medium effect size. The role of average BAC as part of a complex model was confirmed by the finding that the lesser statistical values in the repeated measures

analysis of covariance model controlling for all covariates excepting average BAC ($F(1,11)$ = 0.746, p = .406, $\eta^2_{Partial}$ = .064, 1 - β = .124). The statistics are shown in Table 67.

Table 67

Block Recall Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Block Recall	Model	36.321	1	36.321	0.746	.406	.064	.124	535.376	11	48.671
	Age	48.177	1	48.177	0.990	.341	.083	.149			
	"Stimulated"	0.460	1	0.460	0.009	.924	.001	.051			
	Test-retest Delay	38.365	1	38.365	0.788	.394	.067	.128			
	RPM	29.735	1	29.735	0.611	.451	.053	.110			

* Type III Sum of Squares

In conclusion, exclusion of the influence of average BAC on differences on the Block Recall subtest was substantial, even accounting for the remaining covariates. When the influence of average BAC was permitted in the model, small interaction statistics were observed for participant age (F = 0.990, p = .341, $\eta^2_{Partial}$ = .083, 1 – β = .149), negating the previously larger influence. Small interactions were also calculated for "Stimulated" (F = 0.009, p = .924, $\eta^2_{Partial}$ = .001, 1 – β = .051), test-retest delay (F = 0.788, p = .394, $\eta^2_{Partial}$ = .067, 1 – β = .128) and the RPM (F = 0.611, p = .451, $\eta^2_{Partial}$ = .053, 1 – β = .110). The findings from the partial, and semi-partial, correlation coefficients revealed that the relationship between average BAC and the differences on the Block Recall subtest had been somewhat attenuated by the influence of participant age.

Visuo-spatial Working Memory. The Visuo-spatial Working Memory subtest repeated measures did not differ significantly over the two conditions (p > .05). As previously, average BAC, participant age and "Stimulated" were necessarily included as covariates on theoretical foundations and the three variable's strong interrelationships given that average BAC was sufficiently correlated with participant age (r = -.581, p = .018) and "Stimulated" (r = .497, p = .050) both of which were statistically significantly correlated with one another (r = -.517, p = .040) creating a merger of the three important covariates. Unlike the Verbal Short-term Memory, Verbal Working Memory and Visuo-spatial Short-term Memory subtests, some components of the Visuo-spatial Working Memory composite were impacted by the test-retest delay period and scores on the Raven's Progressive Matrices (Standard Form). Test-retest delay was statistically significantly associated with the repeated measures differences on the Odd-one-out subtest (r = .697, p = .003) and the Odd-one-out Processing score (r = .594, p = .015), as well as the composite score (r = .626, p = .010). Additionally, moderate correlations with

promising probability values were observed between the test-retest delay period and repeated measures differences on the Mister X Processing score (r = .449, p = .081) and Spatial Recall Processing score (r = .480, p = .060). The linear interaction between the RPM and the Odd-one-out subtest repeated measures differences value was statistically significant (r = .514, p = .041) whilst that for the concomitant processing score was moderate although not statistically significant (r = .445, p = .084). The earlier section on additional covariates details the full correlational results between the repeated measures differences, test-retest delay and the RPM which are reported in-text within each section model later in this text. The next sections assess the influence of the covariates on the repeated measures of the AWMA Visuo-spatial Working Memory subtests. Table 68 shows the analysis of covariance models excluding the influence of average BAC.

In comparison to the analysis of variance models, Table 68 shows some changes in the F statistics, and effect sizes, for certain subtests which are detailed later in this section. Participant age was correlated with average BAC (r = -.581, p = .018), implying that younger participants recorded larger BAC readings as well as tendencies towards deteriorations in performance under the experimental condition. Table 69 shows the analysis of covariance models for the Visuo-spatial Working Memory components where participant age is controlled for. Table 70 shows the repeated measures analysis of covariance models controlling for both average BAC and participant age.

Control for the variable age resulted in substantial changes in some of the model F statistics and effect sizes. The alterations reinforce the importance of controlling for participant age when assessing differences over repeated measures perhaps related to alcohol consumption. Likewise, control for both average BAC and age resulted in changes to the model statistics in comparison to the original analysis of covariance model. For some subtests the changes were reflected in statistically significant probability values ($p < .05$). This information is discussed in detail in the subtest specific reporting sections to follow. Models controlling for the "Stimulated" scale are reported in Table 71 and Table 72 shows the repeated measures analysis of covariance models controlling for both average BAC and "Stimulated".

Table 68

Visuo-spatial Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-One-Out	29.546	1	29.546	.645	.435	.044	.116	95.129	1	95.129	2.077	.172	.129	.269	641.340	14	45.810
Mister X	71.274	1	71.274	.934	.350	.063	.147	5.070	1	5.070	.066	.800	.005	.057	1068.899	14	76.350
Spatial Recall	2.455	1	2.455	.084	.776	.006	.058	.085	1	.085	.003	.958	.000	.050	408.383	14	29.170

* Type III Sum of Squares

Table 69

Visuo-spatial Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Participant Age (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	238.048	1	238.048	6.601	.022	.320	.667	231.605	1	231.605	6.422	.024	.314	.655	504.864	14	36.062
Mister X	256.895	1	256.895	4.222	.059	.232	.481	222.183	1	222.183	3.652	.077	.207	.429	851.786	14	60.842
Spatial Recall	0.611	1	0.611	0.021	.887	.001	.052	0.212	1	0.212	0.007	.933	.001	.051	408.257	14	29.161

* Type III Sum of Squares

Table 70

Visuo-spatial Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and Participant Age (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	Model	118.366	1	118.366	3.056	.104	.190	.367	503.595	13	38.738
	BAC	1.268	1	1.268	0.033	.859	.003	.053			
	Age	137.745	1	137.745	3.556	.082	.215	.416			
Mister X	Model	436.139	1	436.139	8.433	.012	.393	.766	672.336	13	51.718
	BAC	179.450	1	179.450	3.470	.085	.211	.407			
	Age	396.563	1	396.563	7.668	.016	.371	.726			
Spatial Recall	Model	0.323	1	0.323	0.010	.921	.001	.051	408.256	13	31.404
	BAC	0.001	1	0.001	0.000	.996	.000	.050			
	Age	0.127	1	0.127	0.004	.950	.000	.050			

* Type III Sum of Squares

Table 71

Visuo-spatial Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for "Stimulated" (n = 16)

	Model			*Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	96.227	1	96.227	2.155	.164	.133	.277	111.401	1	111.401	2.495	.137	.151	.313	625.068	14	44.648
Mister X	30.845	1	30.845	0.426	.525	.030	.093	59.738	1	59.738	0.825	.379	.056	.135	1014.231	14	72.445
Spatial Recall	2.315	1	2.315	0.080	.782	.006	.058	1.022	1	1.022	0.035	.854	.003	.054	407.447	14	29.103

* Type III Sum of Squares

Table 72

Visuo-spatial Working Memory AWMA Subtests Repeated Measures Analysis of Covariance Model Controlling for Average BAC and "Stimulated" (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	Model	61.695	1	61.695	1.341	.268	.094	.189	598.057	13	46.004
	BAC	27.011	1	27.011	0.587	.457	.043	.110			
	"Stimulated"	43.283	1	43.283	0.941	.350	.067	.147			
Mister X	Model	54.278	1	54.278	0.731	.408	.053	.125	964.982	13	74.229
	BAC	49.248	1	49.248	0.663	.430	.049	.118			
	"Stimulated"	103.917	1	103.917	1.400	.258	.097	.195			
Spatial Recall	Model	2.968	1	2.968	0.095	.763	.007	.059	406.610	13	31.278
	BAC	0.837	1	0.837	0.027	.873	.002	.053			
	"Stimulated"	1.774	1	1.774	0.057	.815	.004	.056			

* Type III Sum of Squares

Table 71 and Table 72 show that control for "Stimulated" in comparisons of the repeated measures means on the Visuo-spatial working memory altered the values of the model statistics in comparison to the original analyses of variance. However, this was only true in specific cases, as discussed in the coming sections, and statistical significance levels were generally not below the α = .05 threshold. Control for both average BAC and "Stimulated" resulted in less dramatic changes to the model statistics. Furthermore, in most cases, the interaction effects did not suggest a strong linear regression relationship between the covariates and the difference score. The two covariates not intrinsically linked to average BAC, namely, test-retest delay and the RPM, were also controlled for in individual models reported in the following sections.

Odd-one-out. The Odd-one-out subtest improvement in performance during the experimental condition ($M_{\text{Difference}}$ = -0.938) was not statistically significant ($F(1,15) = 0.143$, $p = .710$, $\eta^2_{Partial} = .009$, $1 - \beta = .065$). Control for average BAC in the repeated measures analysis of covariance model resulted in a negligible increase in the model statistics ($F(1,14) = 0.645$, $p = .435$, $\eta^2_{Partial}$, = .044, $1 - \beta = .116$). The interaction between average BAC and the Odd-one-out repeated measures difference values was stronger than that seen for some other subtests ($F = 2.077$, $p = .172$, $\eta^2_{Partial} = .129$, $1 - \beta = .269$). The medium effect size suggests some linear relationship as a negative correlation between average BAC and differences over the repeated measures on the Odd-one-out subtest ($r = -.359$, $p = .172$), implying that participants with higher average BAC readings tended towards smaller deteriorations, or improvements, in performance. The influence of the relationship between average BAC and participant age ($r = -.581$, $p = .018$) may have contributed to this finding.

Control for the influence of participant age in the repeated measures analysis of covariance resulted in a substantial increase in the model statistics, as well as statistical significance ($F(1,14) = 6.601$, $p = .022$, $\eta^2_{Partial} = .320$, $1 - \beta = .667$). Furthermore, a statistically significant interaction for the covariate was present ($F = 6.422$, $p = .024$, $\eta^2_{Partial} = .314$, $1 - \beta = .655$), reflecting the linear correlation between the repeated measures differences on the Odd-one-out subtest and participant age ($r = .561$, $p = .024$). Participants who were older tended towards deteriorations in performance, as well as lower average BAC levels, consistent with the correlational findings between the repeated measures differences and average BAC ($r = -.359$, $p = .172$).

Control for both average BAC and participant age in a single model also resulted in model statistics which were considerably larger than those for the analysis of variance model ($F(1,13) = 3.056$, $p = .104$, $\eta^2_{Partial} = .190$, $1 - \beta = .367$). The large effect size implies a worthwhile magnitude of the differences between the repeated measures when the two variables are controlled for. Only participant age was substantially related to the differences in this model ($F = 3.556$, $p = .082$, $\eta^2_{Partial} = .215$, $1 - \beta = .416$) whilst the interaction of average BAC within the model was negligible ($F = 0.033$, $p = .859$, $\eta^2_{Partial} = .003$, $1 - \beta = .053$). The moderate, negative, correlation between the average BAC values and the Odd-one-out subtest repeated measures differences ($r = -.359$, $p = .172$) tended towards zero when the influence of participant age was excluded, showing consistency between the partial correlation coefficient ($r = -.050$, $p = .859$) and semi-partial correlation coefficient ($r = -.042$, $p = .859$). The correlational findings suggest that the negative association between average BAC and the repeated measures differences was partially the product of the negative relationship between participant age and average BAC ($r = -.581$, $p = .018$). Average BAC was also correlated with "Stimulated" ($r = .497$, $p = .050$) which, in turn, was negatively correlated with participant age ($r = -.517$, $p = .040$) in the expected pattern.

When the influence of "Stimulated" was controlled for in a repeated measures analysis of covariance model, the Odd-one-out subtest repeated measures did not differ significantly but the value of the F statistic increased considerably in comparison to the original model ($F(1,14) = 2.155$, $p = .164$, $\eta^2_{Partial} = .133$, $1 - \beta = .277$). A moderate linear relationship was present ($r = -.389$, $p = .137$). Like that for average BAC, the correlation coefficient was negative implying tendencies towards improved performance when subjective stimulation was higher early in the assessment. This interaction was not statistically significant, but a large effect size was computed ($F = 2.495$, $p = .137$, $\eta^2_{Partial} = .151$, $1 - \beta = .313$).

Further control of the covariates in a model controlled for the influence of both average BAC and "Stimulated" produced a model with some increase in statistical values over and above the original analysis of variance although the effect size was not substantial ($F(1,13) = 1.341$, $p = .268$, $\eta^2_{Partial} = .094$, $1 - \beta = .189$). Unlike the repeated measures analysis of variance model controlling for both average BAC and participant age, small linear interactions were evident for average BAC ($F = 0.587$, $p = .457$, $\eta^2_{Partial} = .043$, $1 - \beta = .110$) and "Stimulated" ($F = 0.941$, $p = .350$, $\eta^2_{Partial} = .067$, $1 - \beta = .147$). Average BAC and differences on the Odd-one-out subtest were negatively correlated ($r = -.359$, $p = .172$) and the relationship only altered slightly when "Stimulated" was excluded using a partial correlation coefficient ($r = -.208$, $p = .457$), or a semi-partial correlation coefficient ($r = -.192$, $p = .457$). This finding implies that despite the association between average BAC and "Stimulated" ($r = .497$, $p = .050$), the interaction between the two was insufficient for the influence of "Stimulated" to alter the relationship between average BAC and differences on the Odd-one-out subtest.

When the influence of test-retest delay was controlled for in the comparison of repeated measures means in an analysis of covariance model for the Odd-one-out subtest, the *F* statistic increased dramatically and statistical significance was achieved ($F(1,14) = 11.560$, $p = .004$, $\eta^2_{Partial} = .452$, $1 - \beta = .885$). The dramatic alteration of the *F* statistic appeared to be a product of a linear interaction between test-retest delay and differences on the repeated measures of the Odd-one-out subtest model ($F = 13.236$, $p = .003$, $\eta^2_{Partial} = .486$, $1 - \beta = .922$). The positive correlation between test-retest delay and differences over the repeated measures on the Odd-one-out subtest ($r = .697$, $p = .003$) indicates the importance of this covariate. Longer delays were associated with deteriorations in performance under the experimental condition, or tendencies towards lesser improvements. Exclusion of variance introduced by the RPM, also identified as an important covariate for the Odd-one-out subtest (see "The influence of the Raven's Progressive Matrices (Standard Form)" earlier in this Chapter), had a similar impact in some respects.

When the RPM was controlled for, the repeated measures analysis of covariance model statistics were enhanced in comparison to the analysis of variance model, and were statistically significant ($F(1,14) = 5.194$, $p = .039$, $\eta^2_{Partial} = .271$, $1 - \beta = .564$). A positive linear relationship was present ($r = .514$, $p = .041$) and was a statistically significant interaction in the model ($F = 5.037$, $p = .041$, $\eta^2_{Partial} = .265$, $1 - \beta = .551$). The positive correlation coefficient ($r = .514$, $p = .041$) suggests that participants scoring higher on the RPM tended towards deteriorations in performance under the experimental condition in a manner which significantly

influences the magnitude of the differences observed. The Odd-one-out subtest repeated measures differences were substantially influenced by participant age, test-retest delay and the RPM whilst the "Stimulated" scale on the B-BAES at points one through four of the assessment had a lesser impact.

The Odd-one-out subtest repeated measures differences showed slight improvement under the experimental condition ($M_{\text{Difference}}$ = -0.938) but the repeated measures analysis of variance did not have a large effect size and was not statistically significant (F(1,15) = 0.143, p = .710, $\eta^2_{Partial}$ = .009, 1 – β = .065). Little change in the statistics was observed after control for average BAC (F(1,14) = 0.645, p = .435, $\eta^2_{Partial}$ = .044, 1 – β = .116) but substantial increases in the statistics were calculated when controlling for participant age (F(1,14) = 6.601, p = .022, $\eta^2_{Partial}$ = .320, 1 – β = .667), "Stimulated" (F(1,14) = 2.155, p = .164, $\eta^2_{Partial}$ = .133, 1 – β = .277), test-retest delay (F(1,14) = 11.560, p = .004, $\eta^2_{Partial}$ = .452, 1 – β = .885) and the RPM (F(1,14) = 5.194, p = .039, $\eta^2_{Partial}$ = .271, 1 – β = .564). Table 73 shows model statistics for the repeated measures analysis of covariance model excluding the influence of all the covariates.

Table 73

Odd-one-out Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	Model	125.324	1	125.324	4.458	.061	.308	.479	281.100	10	28.110
	BAC	1.364	1	1.364	0.049	.830	.005	.055			
	Age	42.577	1	42.577	1.515	.247	.132	.200			
	"Stimulated"	17.365	1	17.365	0.618	.450	.058	.110			
	Test-retest Delay	100.252	1	100.252	3.566	.088	.263	.401			
	RPM	52.701	1	52.701	1.875	.201	.158	.236			

* Type III Sum of Squares

When all the covariates were controlled for, the model approached statistical significance with a large effect size (F(1,10) = 4.458, p = .061, $\eta^2_{Partial}$ = .308, 1 – β = .479). The interactions show a large linear influence from the test-retest delay covariate (F = 3.566, p = .088, $\eta^2_{Partial}$ = .263, 1 – β = .401) with lesser influences from participant age (F = 1.515, p = .247, $\eta^2_{Partial}$ = .132, 1 – β = .200) and the RPM (F = 1.875, p = .201, $\eta^2_{Partial}$ = .158, 1 – β = .236). Only small interaction statistics were observed for average BAC (F = 0.049, p = .830, $\eta^2_{Partial}$ = .005, 1 – β = .055) and "Stimulated" (F = 0.618, p = .450, $\eta^2_{Partial}$ = .058, 1 – β = .110). These findings suggest a minimal influence of average BAC in attenuating the differences within the model. The strong, but not significant, influence of test-retest delay was

confirmed by a model excluding the influence of all covariates except average BAC. This model, shown in Table 74, shows an important effect of the covariates in the differences observed, allowing average BAC to have been included in the now statistically significant repeated measures differences ($F(1,11) = 5.137$, $p = .045$, $\eta^2_{Partial} = .318$, $1 - \beta = .543$).

Table 74

Odd-one-out Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Odd-one-out	Model	131.921	1	131.921	5.137	.045	.318	.543	282.464	11	25.679
	Age	44.250	1	44.250	1.723	.216	.135	.224			
	"Stimulated"	20.648	1	20.648	0.804	.389	.068	.130			
	Test-retest Delay	101.184	1	101.184	3.940	.073	.264	.441			
	RPM	51.339	1	51.339	1.999	.185	.154	.253			

* Type III Sum of Squares

In terms of attenuating the differences in the original repeated measures analysis of variance model ($F(1,15) = 0.143$, $p = .710$, $\eta^2_{Partial} = .009$, $1 - \beta = .065$), linear interactions with large effect sizes were calculated for test-retest delay ($F = 3.940$, $p = .073$, $\eta^2_{Partial} = .264$, $1 - \beta = .441$) and the RPM ($F = 1.999$, $p = .185$, $\eta^2_{Partial} = .154$, $1 - \beta = .253$). Furthermore, a medium effect size was present for the interaction of participant age within the model ($F = 1.723$, $p = .216$, $\eta^2_{Partial} = .135$, $1 - \beta = .224$). The impact of "Stimulated" on the differences appeared to be negligible ($F = 0.804$, $p = .389$, $\eta^2_{Partial} = .068$, $1 - \beta = .130$). The findings demonstrate that with, or without, the influence of average BAC, test-retest delay and the RPM appear to have substantially influenced the repeated measures differences.

Mister X. Performance on the Mister X subtest improved under the experimental condition ($M_{Difference} = -3.563$) although the differences were not statistically significant without a large effect size ($F(1,15) = 1.418$, $p = .252$, $\eta^2_{Partial} = .086$, $1 - \beta = .200$). Exclusion of the influence of average BAC from the analysis of variance did create a change in the magnitude of the model statistics, decreasing their values ($F(1,14) = 0.934$, $p = .350$, $\eta^2_{Partial} = .063$, $1 - \beta = .147$) and the interaction for average BAC within the model did not suggest the presence of a useful linear regression model between the covariate and the difference score ($F = 0.066$, $p = .800$, $\eta^2_{Partial} = .005$, $1 - \beta = .057$). These findings suggest that variance introduced by average BAC did not substantially impact differences on the Mister X subtest in a linear manner. The weak correlation between average BAC and the repeated measures differences on the Mister X subtest scores shows the relationship between the two measures ($r = .069$, $p = .800$). However, participant age was more closely associated with these differences ($r = .455$,

p = .077), and correlated with average BAC (r = -.581, p = .018), implying tendencies towards deteriorations with greater age as well as tendencies towards lower average BAC levels with greater age.

Exclusion of the influence of participant age magnified the statistical values of the repeated measures analysis of covariance model (F(1,14) = 4.222, p = .059, $\eta^2_{Partial}$ = .232, 1 – β = .481) with a large effect size of the linear interaction (F = 3.652, p = .077, $\eta^2_{Partial}$ = .207, 1 – β = .429). The findings show that participant age had a substantial influence in attenuating differences over the repeated measures on the Mister X subtest whilst the removal of the influence of average BAC reduced the statistical magnitude of the differences.

Control for both average BAC and participant age resulted in a statistically significant model (F(1,13) = 8.433, p = .012, $\eta^2_{Partial}$ = .393, 1 – β = .766) with a large effect size of the linear interaction for average BAC (F = 3.470, p = .085, $\eta^2_{Partial}$ = .211, 1 – β = .411) and a strong linear interaction for participant age (F = 7.668, p = .016, $\eta^2_{Partial}$ = .371, 1 – β = .726). The insubstantial zero-order correlation coefficient between average BAC and differences on the repeated measures of Mister X (r = .069, p = .800) was greatly strengthened when participant age was partialled out (r = .459, p = .085). A similar value was calculated for the semi-partial correlation coefficient (r = .409, p = .085). The influence of age negatively attenuated the relationship between average BAC and the repeated measures differences on the Mister X subtest. The increase to a moderate, positive, correlation coefficient suggests an association between the repeated measures differences and average BAC masked by the introduction of variance from participant age. An impact was also found for “Stimulated”, known to be associated with both average BAC (r = .497, p = .050) and participant age (r = -.517, p = .040).

Removal of the influence of “Stimulated” resulted in a reduction of the F statistic of the repeated measures model (F(1,14) = 0.426, p = .525, $\eta^2_{Partial}$ = .030, 1 – β = .093). The original analysis of variance model statistics were somewhat stronger (F(1,15) = 1.418, p = .252, $\eta^2_{Partial}$ = .086, 1 – β = .200). The reduction in the F statistic implies a magnifying effect of the inclusion of “Stimulated” in the comparisons of the repeated measures. No large linear interaction was present (F = 0.825, p = .379, $\eta^2_{Partial}$ = .056, 1 – β = .135). The interaction’s correlation coefficient, as a linear model to the difference score, implied that greater feelings of “Stimulated” were associated with improvements in performance under the experimental condition (r = -.236, p = .379).

The original model statistics were not substantially different to the repeated measures analysis of covariance model controlling for the influence of both average BAC and "Stimulated" ($F(1,13) = 0.731$, $p = .408$, $\eta^2_{Partial} = .053$, $1 - \beta = .125$). The linear interaction effects were not powerful for either average BAC ($F = 0.663$, $p = .430$, $\eta^2_{Partial} = .049$, $1 - \beta = .118$) or "Stimulated" ($F = 1.400$, $p = .258$, $\eta^2_{Partial} = .097$, $1 - \beta = .195$). As reported, the zero-order correlation coefficient between repeated measures differences on the Mister X subtest and average BAC readings was close to zero ($r = .069$, $p = .800$). This correlational relationship was altered by the removal of "Stimulated" using a partial correlation coefficient ($r = .220$, $p = .430$) and semi-partial correlation coefficient ($r = .214$, $p = .430$). The changes in the correlational relationship suggest that "Stimulated" did contribute as some source of variance in the relationship between average BAC and differences on the Mister X repeated measures. When the influence of "Stimulated" was removed, the relationship tended towards a positive one, as theoretically expected. Test-retest delay created a similar response.

When the influence of test-retest delay was excluded in a repeated measures analysis of covariance on the Mister X subtest, an increase in the magnitude of the model statistics was seen in comparison to the original analysis of variance model ($F(1,14) = 3.276$, $p = .092$, $\eta^2_{Partial} = .189$, $1 - \beta = .391$) and the linear interaction was medium in effect size ($F = 1.897$, $p = .190$, $\eta^2_{Partial} = .119$, $1 - \beta = .250$). The relationship between test-retest delay and differences on the Mister X subtest was positive, suggesting that shorter delays between assessments resulted in a tendency towards improvement in performance ($r = .345$, $p = .190$). The findings reveal that some interaction was present between the repeated measures of Mister X and test-retest delay.

The Mister X subtest scores did not differ significantly between conditions ($F(1,15) = 1.418$, $p = .252$, $\eta^2_{Partial} = .086$, $1 - \beta = .200$) and the statistical values lessened when the influence of the RPM was removed ($F(1,14) = 0.001$, $p = .977$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). The RPM was not correlated with the differences on the Mister X subtest ($r = -.044$, $p = .870$) resulting in no statistically significant interaction effect ($F = 0.028$, $p = .870$, $\eta^2_{Partial} = .002$, $1 - \beta = .053$).

The findings concerning the Mister X subtest improvements ($M_{\text{Difference}} = -3.563$) reveal increased statistical values in comparison to the original analysis of variance statistics ($F(1,15) = 1.418$, $p = .252$, $\eta^2_{Partial} = .086$, $1 - \beta = .200$) created by the control of the influence of participant age ($F(1,14) = 4.222$, $p = .059$, $\eta^2_{Partial} = .232$, $1 - \beta = .481$) and test-retest delay ($F(1,14) = 3.276$, $p = .092$, $\eta^2_{Partial} = .189$, $1 - \beta = .391$), as well as a reduction after the control

of "Stimulated" ($F(1,14) = 0.426$, $p = .525$, $\eta^2_{Partial} = .030$, $1 - \beta = .093$). A slight change in the statistical values was noted when average BAC was controlled for ($F(1,14) = 0.934$, $p = .350$, $\eta^2_{Partial} = .063$, $1 - \beta = .147$). When the RPM was controlled for, the model statistics reduced in magnitude ($F(1,14) = 0.001$, $p = .977$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$). Table 75 shows the repeated measures analysis of covariance model statistics for a full model controlling for these covariates to assess the repeated measures differences.

Table 75

Mister X Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Mister X	Model	77.765	1	77.765	1.250	.290	.111	.173	621.980	10	62.198
	BAC	173.143	1	173.143	2.784	.126	.218	.327			
	Age	215.582	1	215.582	3.466	.092	.257	.391			
	"Stimulated"	2.362	1	2.362	0.038	.849	.004	.054			
	Test-retest Delay	27.756	1	27.756	0.446	.519	.043	.093			
	RPM	16.314	1	16.314	0.262	.620	.026	.075			

* Type III Sum of Squares

The repeated measures analysis of covariance model controlling for all the covariates was not statistically significant and was similar to the original model in terms of statistical values ($F(1,10) = 1.250$, $p = .290$, $\eta^2_{Partial} = .111$, $1 - \beta = .173$). Linearly, the interaction for participant age was of a large effect size ($F = 3.466$, $p = .092$, $\eta^2_{Partial} = .257$, $1 - \beta = .391$), as was that for average BAC ($F = 2.784$, $p = .126$, $\eta^2_{Partial} = .218$, $1 - \beta = .327$), suggesting an important influence of these two covariates on the difference score for the Mister X subtest. Small statistics of interaction were calculated for "Stimulated" ($F = 0.038$, $p = .849$, $\eta^2_{Partial} = .004$, $1 - \beta = .054$), test-retest delay ($F = 0.446$, $p = .519$, $\eta^2_{Partial} = .043$, $1 - \beta = .093$) and the RPM ($F = 0.262$, $p = .620$, $\eta^2_{Partial} = .026$, $1 - \beta = .075$). Earlier, correlational studies were discussed in which control for participant age greatly enhanced the relationship between average BAC and differences on the Mister X subtest. This is apparent in the model in Table 76, showing substantially reduced statistics of difference when the influence of average BAC is not controlled for.

Table 76

Mister X Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Mister X	Model	21.201	1	21.201	0.293	.599	.026	.079	795.124	11	72.284
	Age	101.556	1	101.556	1.405	.261	.113	.192			
	"Stimulated"	2.090	1	2.090	0.029	.868	.003	.053			
	Test-retest Delay	32.799	1	32.799	0.454	.514	.040	.095			
	RPM	40.208	1	40.208	0.556	.471	.048	.105			

* Type III Sum of Squares

The repeated measures analysis of covariance model controlling for age, "Stimulated", test-retest delay and the RPM was not statistically significant, nor was the effect size substantial ($F(1,11) = 0.293$, $p = .599$, $\eta^2_{Partial} = .026$, $1 - \beta = .079$). The model statistics were considerably smaller than those reported in the original analysis of variance model inclusive of all these influences ($F(1,15) = 1.418$, $p = .252$, $\eta^2_{Partial} = .086$, $1 - \beta = .200$). The interactions were minimal for "Stimulated" ($F = 0.029$, $p = .868$, $\eta^2_{Partial} = .003$, $1 - \beta = .053$), test-retest delay ($F = 0.454$, $p = .514$, $\eta^2_{Partial} = .040$, $1 - \beta = .095$) and the RPM ($F = 0.556$, $p = .471$, $\eta^2_{Partial} = .048$, $1 - \beta = .105$). A slightly larger interaction, with a medium effect size, was calculated for participant age ($F = 1.405$, $p = .261$, $\eta^2_{Partial} = .113$, $1 - \beta = .192$). The comparison of the two full models implies that average BAC, possibly in combination with participant age, had an attenuating effect on the statistical magnitude of the differences, whereby inclusion of its influence reduced the magnitude of the statistics of difference.

Spatial Recall. The Spatial Recall repeated measures difference showed a slight deterioration in performance under the experimental condition ($M_{\text{Difference}} = 0.938$), but the difference was not statistically significant, nor was a substantial effect size present in the model ($F(1,15) = 0.258$, $p = .619$, $\eta^2_{Partial} = .017$, $1 - \beta = .258$). Control of the influence of average BAC did not substantially alter the statistics of the model as a repeated measures analysis of covariance ($F(1,14) = 0.084$, $p = .776$, $\eta^2_{Partial} = .006$, $1 - \beta = .058$) and no linear interaction was present ($F = 0.003$, $p = .958$, $\eta^2_{Partial} = .000$, $1 - \beta = .050$), nor was the associated correlation between average BAC and differences on the Spatial Recall subtest ($r = .014$, $p = .958$).

Exclusion of the influence of the covariate "Age", correlated to average BAC ($r = -.581$, $p = .018$), did not substantially influence the *F* statistic, or effect size, of the repeated measures model ($F(1,14) = 0.021$, $p = .887$, $\eta^2_{Partial} = .001$, $1 - \beta = .052$). The model statistics remained small, and no statistically strong interaction of the covariate within the model was

calculated (F = 0.007, p = .933, $\eta^2_{Partial}$ = .001, 1 – β = .051). The correlation between participant age and the repeated measures differences on the Spatial Recall subtest was negligible (r = -.023, p = .933).

When the influence of both average BAC and participant age were controlled for in a repeated measures analysis of covariance model, very similar findings were computed (F(1,13) = 0.010, p = .921, $\eta^2_{Partial}$ = .001, 1 – β = .051). There were very small interaction statistics for average BAC (F = 0.000, p = .996, $\eta^2_{Partial}$ = .000, 1 – β = .000) and participant age (F = 0.004, p = .950, $\eta^2_{Partial}$ = .000, 1 – β = .050). The zero-order correlation between average BAC and the repeated measures differences on the Spatial Recall subtest (r = .014, p = .958) was not substantially altered when the influence of participant age was removed through the calculation of a partial correlation coefficient (r = .001, p = .996) and semi-partial correlation coefficient (r = .002, p = .996). The average BAC value's association with the "Stimulated" scale (r = .497, p = .050) was sufficient to assume "Stimulated" would behave similarly as a covariate given the association between "Stimulated" and participant age (r = -.517, p = .040).

Exclusion of the influence of "Stimulated" also did not substantially increase, or decrease, the F statistic and effect size of the model (F(1,14) = 0.080, p = .782, $\eta^2_{Partial}$ = .006, 1 – β = .058) and no linear association as an interaction was present (F = 0.035, p = .854, $\eta^2_{Partial}$ = .003, 1 – β = .054). The scale "Stimulated" was not correlated with the repeated measures differences on the Spatial Recall subtest (r = -.050, p = .854).

Exclusion of both average BAC and "Stimulated" reaffirmed this supposition with small model statistics being computed (F(1,13) = 0.095, p = .763, $\eta^2_{Partial}$ = .007, 1 – β = .059). No statistically substantial interaction was observed for either average BAC (F = 0.027, p = .873, $\eta^2_{Partial}$ = .002, 1 – β = .053) or "Stimulated" (F = 0.057, p = .815, $\eta^2_{Partial}$ = .004, 1 – β = .056). The zero-order correlation coefficient between average BAC and the repeated measures differences on the Spatial Recall subtest (r = .014, p = .958) was not substantially increased by the exclusion of "Stimulated" when a partial correlation coefficient was calculated (r = .045, p = .873). The calculated semi-partial correlation coefficient was identical in value (r = .045, p = .873). The findings suggest that "Stimulated", as a covariate, was not of importance in understanding the differences observed between the repeated measures of the Spatial Recall subtest or in their association with average BAC.

Control for the influence of test-retest delay in the repeated measures comparison on the Spatial Recall subtest resulted in small changes in the model statistics (F(1,14) = 0.422, p = .527, $\eta^2_{Partial}$ = .029, 1 – β = .093) which were very similar to those of the original analysis

of variance model ($F(1,15) = 0.258$, $p = .619$, $\eta^2_{Partial} = .017$, $1 - \beta = .258$). In comparison to the other two covariates, the correlation between test-retest delay and the repeated measures differences values was slightly stronger ($r = .270$, $p = .312$). No statistically substantial interaction was present within the repeated measures analysis of covariance model ($F = 1.100$, $p = .312$, $\eta^2_{Partial} = .073$, $1 - \beta = .165$). Although some tendency towards deteriorations in performance given longer test-retest delays was evident, the model and interaction statistics did not support a strong influence of test-retest delay as a covariate.

Under conditions where the influence of the RPM was removed, the model's statistical values increased without statistical significance being achieved ($F(1,14) = 1.037$, $p = .326$, $\eta^2_{Partial} = .069$, $1 - \beta = .158$). No statistically significant correlation coefficient ($r = .279$, $p = .296$) and interaction ($F = 1.180$, $p = .296$, $\eta^2_{Partial} = .078$, $1 - \beta = .173$) was calculated. The slight positive slope of the Pearson's *r* value does suggest that greater scores on the RPM may be associated with deteriorations in performance on Spatial Recall under the experimental condition. The increase in the *F* values presented under the covariance conditions, alongside the positive correlation coefficient, suggests that the RPM may have had a small influence in determining the outcome of the comparisons.

The findings following the assessment of the repeated measures differences on the Spatial Recall subtest ($M_{\text{Difference}} = 0.938$) suggested little influence from any of the identified covariates. The repeated measures analysis of variance model ($F(1,15) = 0.258$, $p = .619$, $\eta^2_{Partial} = .017$, $1 - \beta = .258$) was not substantially altered in comparison to repeated measures analysis of covariance models to control for participant age ($F(1,14) = 0.021$, $p = .887$, $\eta^2_{Partial} = .001$, $1 - \beta = .052$), subjective "Stimulated" scale congruence ($F(1,14) = 0.080$, $p = .782$, $\eta^2_{Partial} = .006$, $1 - \beta = .058$) or test-retest delay ($F(1,14) = 0.422$, $p = .527$, $\eta^2_{Partial} = .029$, $1 - \beta = .093$). A small increase in the statistics was calculated following control for the RPM ($F(1,14) = 1.037$, $p = .326$, $\eta^2_{Partial} = .069$, $1 - \beta = .158$), but not average BAC ($F(1,14) = 0.084$, $p = .776$, $\eta^2_{Partial} = .006$, $1 - \beta = .058$). Table 77 shows the repeated measures analysis of covariance model controlling for all these minimal influences.

Table 77

Spatial Recall Repeated Measures Analysis of Covariance Model Controlling for Average BAC, Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Spatial Recall	Model	4.834	1	4.834	0.143	.713	.014	.064	338.501	10	33.850
	BAC	1.485	1	1.485	0.044	.838	.004	.054			
	Age	6.469	1	6.469	0.191	.671	.019	.068			
	"Stimulated"	6.193	1	6.193	0.183	.678	.018	.067			
	Test-retest Delay	33.353	1	33.353	0.985	.344	.090	.147			
	RPM	15.135	1	15.135	0.447	.519	.043	.093			

* Type III Sum of Squares

Minor change to the model statistics was observed when all covariates were controlled for (F(1,10) = 0.143, p = .713, $\eta^2_{Partial}$ = .014, 1 – β = .064). Additionally, only weak linear interactions were present for average BAC (F = 0.044, p = .838, $\eta^2_{Partial}$ = .004, 1 – β = .054), participant age (F = 0.191, p = .671, $\eta^2_{Partial}$ = .019, 1 – β = .068), "Stimulated" (F = 0.183, p = .678, $\eta^2_{Partial}$ = .018, 1 – β = .067), test-retest delay (F= 0.985, p = .344, $\eta^2_{Partial}$ = .090, 1 – β = .147) and the RPM (F = 0.447, p = .519, $\eta^2_{Partial}$ = .043, 1 – β = .093). These findings imply that little statistical difference existed between the Spatial Recall subtest repeated measures regardless of the influence of the covariates. A repeated measures analysis of covariance model was calculated to control for the influence of all covariates except average BAC. These statistics are shown in Table 78.

Table 78

Spatial Recall Repeated Measures Analysis of Covariance Model Controlling for Participant Age, "Stimulated", Test-retest Delay and the RPM (n = 16)

		Model			*Statistics*				*Error*		
		*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Spatial Recall	Model	3.597	1	3.597	0.116	.739	.010	.061	339.986	11	30.908
	Age	11.360	1	11.360	0.368	.557	.032	.086			
	"Stimulated"	8.027	1	8.027	0.260	.620	.023	.075			
	Test-retest Delay	33.882	1	33.882	1.096	.318	.091	.160			
	RPM	13.978	1	13.978	0.452	.515	.039	.094			

* Type III Sum of Squares

Table 78 shows the repeated measures analysis of covariance models excluding all covariates excepting average BAC. The statistics calculated were almost identical to those for other models (F(1,11) = 0.116, p = .739, $\eta^2_{Partial}$ = .010, 1 – β = .061). Aside from the absence of statistically meaningful differences, little linear interaction of the covariates was observed in the model. Test-retest delay showed the strongest interaction with the difference score under these circumstances (F = 1.096, p = .318, $\eta^2_{Partial}$ = .091, 1 – β = .160). Interactions were very small, for participant age (F = 0.368, p = .557, $\eta^2_{Partial}$ = .032, 1 – β = .086), "Stimulated" (F

= 0.260, p = .620, $\eta^2_{Partial}$ = .023, 1 – β = .075) and the RPM (F = 0.452, p = .515, $\eta^2_{Partial}$ = .039, 1 – β = .094). These findings show that no statistical differences were apparent over the repeated measures of the Spatial Recall subtest whether, or not, the covariates were included.

Analysis of the findings for the AWMA subtests controlling for the identified covariates resulted in changes in the F statistics, and effect sizes, in comparison to the normal repeated measures analysis of variance models. The findings imply a differential impact of the covariates dependent upon specific combinations and the subtest in question. The close interrelationships between average BAC, participant age and the derived scale, "Stimulated", measuring subjective stimulation in the early portions of the assessment suggested an intertwining of influences. Meanwhile, test-retest delay had an impact only in some cases, reducing the likelihood of general practice effects as influential across the assessment. The RPM, considered as a covariate for the Visuo-spatial Short-term Memory and Visuo-spatial Working Memory subtests, also did not have a consistent impact on the statistics.

The inferential findings suggested that alcohol had little specific effect on the short-term memory tasks, which generally showed declines, or no change, under the experimental condition. This was also the case for the Mazes Memory subtest on which performance declined substantially under the experimental condition. For the short-term memory subtests, participant age and average BAC had variable effects, in some cases enhancing the differences observed following alcohol consumption. In general, the relationship between differences on the short-term memory subtests and average BAC was enhanced when participant age was controlled for. More influential changes in performance were observed on the Verbal, and Visuo-spatial, Working Memory tasks, except the Spatial Recall subtest. Both sets of working memory scores increased under the experimental condition suggesting a global change in the working memory functioning. As for the short-term memory subtests, control for participant age enhanced the relationship between the differences in performance and average BAC. Based on the partial correlations, and since breath alcohol concentrations were not clearly linearly related to performance changes on any of the tasks, it appeared that the effect of alcohol was partially dependent on participant age. Resultantly, it is challenging to conclude whether alcohol consumption alone, particularly at such a low dose, was primarily responsible for changes in performance. The next chapter considers the results of the research regarding the influence of both alcohol and the other covariates in producing changes in performance on the AWMA subtests under the experimental condition.

Chapter 7

Discussion and Findings

Discussion

Strengths and Limitations

Conclusion

Discussion

This chapter discusses the findings of the present research in context of published literature. Examination of the results of the statistical analyses revealed several trends and themes related to the research questions. The findings were both congruent and incongruent with those of other researchers and of interest in terms of additional influences, many of which were not fully explored in other studies. Some important outcomes of the present research included differential impacts of a low dose of alcohol on short-term memory versus working memory and the specific influence of average breath alcohol concentration (BAC) readings. Although average BAC readings resulting from alcohol consumption were found to have influenced the outcome of the repeated measures comparisons in many cases, it was also important to debate the role of covariates such as participant age, subjective perceptions of stimulation and test-retest delay. These covariates were important due to their interactions with average BAC and influence on the statistical models. The specific relationship between fluid intelligence and both short-term and working memory tasks was also examined. The inclusion of covariates contributed to a better understanding of the disaggregated findings when the literature is compared. The present research is unique in its consideration of this array of potential influences and, therefore, the discussion of the findings is presented in context of each of these aspects.

Acute alcohol consumption, as measured by average BAC readings, was shown to affect the subtests measuring short-term memory differently to those measuring working memory. The effect on the short-term memory tasks also differed depending on task type. Deteriorations in performance were observed for the Nonword Recall subtest measuring Verbal Short-term Memory. Furthermore, a substantial effect size was calculated for the deterioration in performance observed on the Mazes Memory subtest which measured Visuo-spatial Short-term Memory. Despite also measuring short-term memory, performance on the other subtests was either negligible, or slightly improved. For these subtests, the values of statistical significance and the effect sizes were generally minimal, except for the Dot Matrix subtest for which the values were slightly larger. While the short-term memory subtests showed variable directions of change over the two conditions, the working memory subtests showed general improvements in performance during the experimental condition.

The Listening Recall, Counting Recall and Backward Digit subtests measuring Verbal Working Memory all showed improvements in performance under the experimental condition. The analyses of variance for these subtests had substantial effect sizes. Although the Odd-one-

out and Mister X subtests also showed improvements in performance under the experimental condition, the effect sizes were smaller for these subtests which measured Visuo-spatial Working Memory. Uniquely, the Spatial Recall subtest showed a negligible change in performance over the repeated measures, despite also measuring Visuo-spatial Working Memory. Understanding the differential influences of alcohol on the various subtests was challenging as other variables, or covariates, were also important. These covariates, which included participant age, altered the observed relationships between breath alcohol readings and the repeated measures differences.

The model statistics reflecting the relationship between average BAC and the repeated measures differences on some of the Automated Working Memory Assessment (AWMA) subtests were magnified when participant age was controlled for. Furthermore, removing the influence of participant age resulted in stronger positive relationships between average BAC readings and differences in performance over the repeated measures. Although consistent, the extent of this influence was different across the subtest types. The working memory processing subtests were most affected by participant age values, while average BAC readings alone were more influential for the short-term memory subtests. Although both average BAC and participant age were also closely related to the derived "Stimulated" scale, which measured subjective feelings of stimulation during the early portions of the assessment, "Stimulated" values did not have the same impact on the findings. Thus, in cases where a minor influence of "Stimulated" was observed, it may have been due to a confounding relationship with average BAC readings rather than a direct influence. Apart from the interrelated influences of average BAC, participant age and subjective perceptions of stimulation on the repeated measures differences, test-retest delay periods also played a role in some cases.

Lengthier test-retest delays were consistently associated with smaller improvements, or deteriorations, in performance over the repeated measures. This was found for all of the Verbal and Visuo-spatial Working Memory subtests, except Spatial Recall. However, of the short-term memory subtests, only the Dot Matrix measure of Visuo-spatial Short-term Memory was affected. Therefore, the findings indicated that the inclusion of a minimum test-retest delay period in the research design was not as effective as intended in avoiding a confounding influence. However, the finding that the working memory subtests were most affected was of interest for further exploration. A final covariate, the Raven's Progressive Matrices (RPM) was examined to thoroughly assess potential influences in the experiment. The RPM was included in the study to ascertain whether this non-verbal measurement of fluid intelligence could have been related to changes observed under the experimental condition. However, the findings did

not support this hypothesis except for the Odd-one-out subtest of Visuo-spatial Working Memory. In terms of the structure of the AWMA in relation to fluid intelligence, the RPM was significantly related to the Visuo-spatial Short-term and Working Memory tasks, but not to any of the verbal tasks. Therefore, a visuo-spatial modality specific relationship may have been present. Consequently, in the discussion that follows, the RPM is mainly considered in terms of its structural relationship to working memory. The forthcoming sections of this chapter considers the variables which appeared to be associated with the differences observed over the repeated measures, particularly in relation to the administration of the low dose of alcohol under the experimental condition. Furthermore, the influences of subjective intoxication, participant age and test-retest delay are considered as individual variables and in relation to acute alcohol consumption. Lastly, a brief discussion of the RPM elaborates on the nature of the association between non-verbal fluid intelligence and working memory, despite the absence of an influence of the RPM on the observed changes in performance during the experiment.

The Influences of Alcohol on the Components of Working Memory

The present study's findings showed that performance on certain short-term and working memory tasks changed following alcohol consumption. However, the subtests and components were affected differently. The effect sizes of the repeated measures comparisons indicated that some short-term subtests deteriorated under the experimental condition, notably the Nonword Recall verbal task and Mazes Memory visuo-spatial task. This was congruent with the majority of the reviewed literature which reported alcohol-related deficits on both short-term and working memory (e.g. Lechner et al., 2016; Saults et al., 2007). However, performance on the working memory subtests consistently improved under the experimental condition, particularly for the Verbal Working Memory, namely, Listening Recall, Counting Recall and Backward Digit. This was contrary to the findings of most comparable studies, although a limited body of research indicated that improvement in certain types of working memory tasks after alcohol consumption is possible (e.g. Carlyle et al., 2017; Klingberg, 2010; Steele & Josephs, 1988). Some factors identified in these studies could be applicable to the present findings and illustrate the complexity of the influence of alcohol on the components of working memory. Task demands were one aspect which differed across the reviewed studies but comparisons of different task types have not often been conducted in other research (cf. Saults et al., 2007). Consequentially, changes in short-term and working memory task performance following alcohol consumption may be partially due to the different task-specific demands, the structure of the tasks and the processes underlying performance.

Short-term memory capacity was differently affected by alcohol consumption than working memory processing task performance. In the present research, performance on the short-term memory tasks declined under the experimental condition while performance on the working memory tasks improved. The observed deterioration in performance on some of the short-term memory tasks was congruent with other research findings, some of which used similar methods to the present research (e.g. Cromer et al., 2010; Dougherty et al., 2000; Lechner et al., 2016; Saults et al., 2007; Weissenborn & Duka, 2003). However, these studies reported global influences of alcohol on all types of short-term memory tasks. Conversely, the present findings showed that not all of the AWMA short-term memory subtests' scores declined during the experimental condition. This finding suggested that factors other than basic storage capacity may be affected by acute alcohol consumption. This hypothesis was presented by Curhan et al. (2014), who contended that the verbal and visuo-spatial domains may be differently affected by alcohol consumption. Thus, other factors underlying performance on short-term memory task performance could have resulted in the observed declines. One influence on short-term memory functions is the formation of stimulus representations, known to be negatively affected by alcohol consumption (e.g. Sklar & Nixon, 2014).

Alcohol-related changes in short-term memory task performance may be due to the influence of alcohol on stimulus discrimination and representation rather than short-term storage capacity (Dougherty et al., 2000). Low doses of alcohol may affect the formation of both auditory and visual sensory representations of stimuli by disrupting sensory-filtering processes (Sklar & Nixon, 2014). Therefore, alcohol consumption may hinder the sensory ability to discriminate between highly similar auditory components (Dougherty et al., 2000). This would have negatively impacted performance on tasks, such as the Nonword Recall subtest, which required the formation of auditory stimulus representations that could not be linked to other contextually-relevant information. If stimulus discrimination and representation was disrupted by alcohol consumption, these contextually-relevant representations could still have been used as a compensatory mechanism to facilitate rehearsal and recall (Curhan et al., 2014; Pitel et al., 2007; Sklar & Nixon, 2014). In such cases, deficits in stimulus representation would not have had the same negative effect on subtests which could be contextually understood and recalled, such as Word Recall. This was found in the present research. The same hypothesis could be applied to abstract representation in the visuo-spatial domain, although less literature was available to expand on this idea.

Research has reported deficits in abstract spatial representation tasks tapping short-term memory processes (Weissenborn & Duka, 2003). These findings may be analogous to the

present study's finding of a disproportionate deterioration in performance on the Mazes Memory subtest, perhaps due to a reliance on the formation of a single context-free image for later recall. A deficit in this type of stimulus representation would be unlikely to affect the serial positioning tasks, such as the Dot Matrix and Block Recall subtests where performance did not deteriorate during the experimental condition. This discrepancy could be due to the visualisation of a progressive pattern rather than the observation of a single presentation. Although a deterioration in stimulus representation abilities may have resulted in the observed deficits on some of the short-term memory subtests, it would not explain the improvements observed on all the working memory processing subtests. However, the content and task demands of the AWMA working memory processing subtests differed from the executive function subtests used in the majority of the reviewed literature.

The reviewed studies on the impact of alcohol on working memory and executive function have utilised a variety of different tasks. Rather than directly investigating the components of working memory processing, many of the reviewed studies primarily used tasks which focused on global executive function processes such as information monitoring (e.g. Trail Making Test in Lechner et al., 2016), planning (e.g. Tower of London Test in Saults et al., 2007) and contingency monitoring (e.g. Wisconsin Card Sorting Test in Lyvers & Tobias-Webb, 2010). In the present research, the working memory tasks focused primarily on stimulus evaluation coupled with recall, which may have been tacit. For example, Alloway (2007) described the Listening Recall subtest as requiring participants to evaluate a sentence as true or false, and then recall the final word of each sentence in order of presentation. In the Visuo-spatial Working Memory composite, the Mister X subtest required the participants to identify whether the ball was being held in the same versus opposite hand, followed by the recollection of the position of the ball in the correct order. Resultantly, the working memory processing tasks required both an evaluation and recall component. These components may have been differently affected by alcohol in comparison to executive function tasks.

Curtin and Fairchild (2003) suggested that stimulus evaluations remain intact following alcohol consumption, but event-related potentials associated with regulative, or "pure" recall, processes are negatively affected. In context of the present findings, this hypothesis suggests that stimulus evaluation may not have been negatively affected by alcohol consumption and that recall in the working memory processing tasks may have functioned in a different way to the short-term memory tasks. The additional time created during the stimulus evaluation process, the potential for tacit recall and the absence of deliberate rehearsal may have influenced the recall component inherent in the AWMA working memory processing subtests.

These task demands may also be associated with different attention allocation functions to those required for short-term memory tasks. Some research regarding the influence of alcohol on attention has suggested that the attentional requirements are different for short-term and working memory tasks (e.g. Bartholow et al., 2003; Schweizer & Vogel-Sprott, 2008). Therefore, the influence of alcohol on attentional processes may impact performance on each task type differentially (Klingberg, 2010).

Attentional functions and allocations are important for short-term and working memory task performance (Klingberg, 2010). Changes in performance following alcohol consumption could be related to the effect of alcohol on the ability to focus attention and to deliberately attend to all of the information presented (Bartholow et al., 2003; Fleming et al., 2013; Schweizer & Vogel-Sprott, 2008; Steele & Josephs, 1988). Short-term memory recall and rehearsal requires deliberate, focused attention for optimal performance and may, therefore, be more prone to deficits following alcohol consumption (e.g. Curtin & Fairchild, 2003; Finn et al., 1999; Lechner et al., 2016). Alternatively, alcohol consumption could result in deficits in deliberate response selection in a variety of contexts (Curtin & Fairchild, 2003). Both of these hypotheses could be considered in context of the present findings which suggested that short-term memory performance was negatively affected by alcohol consumption due to changes in deliberate rehearsal, recall and response selections. These assumptions would not explain the different effects of alcohol on the various AWMA short-term memory task types, or the improvements observed on the working memory processing tasks. However, related changes in attention may have facilitated performance on these tasks.

A diffuse attentional state following alcohol consumption could be beneficial for broad stimulus evaluation, subliminal rehearsal for recall (Carlyle et al., 2017), reduced susceptibility to distraction without influencing general stimulus evaluation (Curtin & Fairchild, 2003; Erblich & Earleywine, 1995) and allowing automatic responding which could facilitate performance (Abroms, Gottlob, & Fillmore, 2006; Maylor, Rabbitt, James, & Kerr, 1990; Schulte, Muller-Oehring, Strasburger, Warzel, & Sabel, 2001; Tracy & Bates, 1999). For example, Jarosz, Colflesh and Wiley (2012) attributed improvements in performance following alcohol consumption on a working memory processing test similar to the AWMA Listening Recall subtest to diffuse, rather than focused, attention which allowed for tacit recall. Since the working memory processing tasks used in the present research required stimulus evaluation prior to recall, automatic or tacit recall functions may have been applied rather than deliberate recall. Resultantly, the hypothesis that stimulus evaluation and automatic responses remain intact following alcohol consumption would explain the absence of deficits on the working

memory processing tasks found in the present research. Therefore, whilst a diffuse attentional state may facilitate the evaluation of stimuli, automatic responses and tacit storage, an inability to allocate effortful attention may hinder rehearsal strategies and deliberate response selection for recall from short-term memory (Ratti et al., 2002). Aside from alterations to rehearsal and recall, directed attention may also be associated with increased self-evaluation of responses (Autin & Croizet, 2012) which may be reduced following alcohol consumption.

Alcohol consumption has been shown to reduce self-awareness of performance, task-demand perceptions and general metacognitive monitoring (Baumeister & Alghamdi, 2015; Eysenck & Calvo, 1992; Hull, 1981; Hull, Levenson, Young, & Sher, 1983; Ridderinkhof et al., 2002). Furthermore, alcohol may facilitate inadvertent learning and memorisation (Carlyle et al., 2017), reduce self-evaluative behaviours and meta-awareness of responses (Cabeza & Nyberg, 2000; Mason et al., 2007; Müller & Knight, 2006; Oscar-Berman & Marinković, 2007), decrease response inhibitions and alter overall information monitoring (Cohen-Gilbert et al., 2017; Müller & Knight, 2006; Park et al., 2011). As a result of these changes, performance on complex, multi-component tasks may be facilitated. For the AWMA working memory tasks, a reduction in deliberate self-evaluation and monitoring could have resulted in higher levels of inadvertent remembering for tacit recall in the working memory processing subtests. Furthermore, activities such as self-checking and order monitoring would have been important for short-term memory recall but not for working memory processing tasks. These actions may have been reduced following alcohol consumption, resulting in the different findings for each task type.

Although the present research findings of improvements in working memory processing tasks following alcohol consumption were incongruent with those of other studies, the deficits on the short-term memory tasks were consistent with the literature (e.g. Lechner et al., 2016; Saults et al., 2007; Weissenborn & Duka, 2003). However, the short-term memory tasks were not equally affected, with some being more prone to deficits than others. The findings suggest that the influence of alcohol on short-term and working memory may be due to a variety of factors, including task-specific requirements and underlying processes such as stimulus representation and attention allocation. However, when the present findings were examined more closely, a linear relationship between average BAC readings and performance changes on the short-term and working memory tasks was observed. In general, these relationships were weak. However, the findings did suggest that higher average BAC readings could be associated with deteriorations in performance, even in cases when overall improvements were observed. The previous section discussed global comparisons and

described the potential sources of the impact of alcohol on the observed differences. The upcoming sections will examine the influences of covariates, particularly participant age, on the apparent relationship between average BAC and the differences in performance between the baseline and experimental conditions.

Participant age. Participant age had a positive effect on the relationship between average BAC readings and changes in performance over the two measurement conditions. This was demonstrated by a magnification of the model statistics of difference. The Word Recall, Digit Recall and the Odd-one-out subtests were most affected. However, age had a negligible effect on the Mazes Memory and Spatial Recall subtests. Therefore, although the strength of the effect of participant age differed, its influence did not depend on task type or whether the task was based on the verbal or visuo-spatial domain. Apart from influencing the model statistics, control for participant age also caused changes to the linear relationship between average BAC and changes in performance. When participant age was controlled for, the relationship between average BAC and change in performance strengthened in a positive direction. Therefore, when age was controlled for higher average BAC readings were more strongly associated with tendencies toward deteriorations in performance in the alcohol consumption condition. The confounding influence might have been a result of the significant negative relationship between participant age and average BAC readings which indicated that younger participants tended to record higher average BAC levels.

Contrary to research demonstrating that older individuals record higher BAC readings following alcohol consumption (e.g. Acheson, Stein, & Swartzwelder, 1998; Jones & Jones, 1980; Tynjälä, Kangastupa, Laatikainen, Aalto, & Niemelä, 2012; Vogel-Sprott & Barrett, 1984), older participants in the present research sample recorded lower average BAC levels. This relationship could not be accounted for by general consumption levels, binge drinking frequency, body mass index or general lifestyle habits. Furthermore, despite recording lower average BAC readings, older participants were also more prone to deteriorated performance on the working memory tasks under the experimental condition. However, the present study's findings were based on a truncated range of BAC readings, due to the low dose of alcohol administered, and were within a limited age bracket. Nonetheless, a combination of age processes and alcohol consumption may have influenced the observed changes in performance.

Research studies have reported changes in short-term and working memory which were associated with advancing age. Normal aging has been associated with deteriorations in a variety of working memory processes, including complex information processing, sensory processing functions and cognitive load capacity (Cappell, Gmeindl, & Reuter-Lorenz, 2010;

Nittrouer et al., 2016; Reuter-Lorenz et al., 2000; Salthouse, 1994; Salthouse, Mitchell, Skovronek, & Babcock, 1989; Schroeder, 2014; Shaw et al., 2006). Older participants are also more likely to have reduced response accuracy and speed, both of which are related to working memory task perfromance and subject to changes following alcohol consumption (Gilbertson, Ceballos, Prather, & Nixon, 2009; Sklar, Gilbertson, Boissoneault, Prather, & Nixon, 2012). Many of these changes have also been associated with alcohol consumption. Although the present findings indicated that age influenced changes in performance following alcohol consumption, normal aging processes were controlled for by using a repeated measures design. Therefore, the changes observed were not likely due to normal aging, particularly since a truncated age bracket of 21-35 years was used. Nonetheless, some interaction between participant ages and alcohol consumption was present and requires further exploration. A limited body of research has explored both alcohol consumption and participant age in relation to working memory task performance (e.g. Acheson et al., 1998; Gilbertson et al., 2009; Vogel-Sprott & Barrett, 1984).

Research studies have suggested that both complex simulation tasks and working memory tasks are affected by alcohol consumption, but that the effect is not dependent on participant age (Vogel-Sprott & Barrett, 1984; Yesavage, Dolhert, & Taylor, 1994). This is contrary to the present findings that participant age played a significant role in altering the relationship between alcohol consumption and changes in working memory task performance. However, Acheson et al. (1998) found greater alcohol-related impairments in semantic and figural memory in participants between 21 and 24 years of age in comparison to those between 25 and 29 years of age. Although Acheson et al. (1998) also used a repeated measures design to control for baseline ability, relationships between BAC levels and participant ages were not reported. Consequently, the comparability to the present findings was somewhat limited and so the different direction of influence could not be more carefully considered. Nonetheless, Acheson et al.'s (1998) findings also suggested that age can influence how alcohol impacts short-term and working memory, even in younger participants.

The present findings suggested that age may have influenced the impact of alcohol on working memory and the limited literature presented in the previous sections supports this contention, although the findings were not always consistent. Nonetheless, it was not possible to draw a conclusive link between participant age and changes in working memory performance following alcohol consumption. Although some studies suggested a disproportionate effect of age and alcohol depending on task type (e.g. Gilbertson et al., 2009), this was not confirmed by the present findings. The present findings did not seem to be

coincidental as the role of age was quite specific and consistent. However, the limited ranges of measurement of both average BAC and participant age may have influenced the statistics. Therefore, the possibility of a coincidental relationship with an unaccounted factor could not be excluded. However, average BAC was also significantly correlated with the "Stimulated" scale derived from the B-BAES and, therefore, subjective feelings of stimulation could also have been influential.

Subjective stimulation. Subjective feelings of stimulation were measured using the Brief Biphasic Alcohol Effects Scale (B-BAES), a shorter version the Biphasic Alcohol Effects Scale (Earleywine & Erblich, 1996; Martin et al., 1993; Rueger & King, 2013). Feelings of beings stimulated during the ascending limb of the BAC curve are common as part of a biphasic effects profile, as are feelings of sedation during the descending limb (Earleywine & Erblich, 1996; Martin et al., 1993; Morean & Corbin, 2010; Quinn & Fromme, 2011). The present research findings matched this profile based on measurements on the B-BAES over multiple time points throughout the assessment. Resultantly, the correlational findings were tentatively congruent with the structure described by validation studies of the B-BAES (Earleywine & Erblich, 1996; Martin et al., 1993; Rueger & King, 2013). However, the present research sample was too small to conduct confirmatory factor analyses. To facilitate the present data analyses, a derived "Stimulated" scale was constructed which reflected the higher levels of average subjective stimulation during the early portions of the assessment. An average sedation scale was not created due to the weaker, less consistent correlations at the end points of the experimental assessment.

Subjective feelings of stimulation did not affect the statistical models examining changes in performance on the working memory subtests following alcohol consumption. This was true despite the fact that subjective stimulation was positively correlated with average BAC readings. Therefore, although average BAC was associated with higher levels of subjective stimulation, feelings of stimulation did not have a substantial influence on the effect of alcohol consumption on short-term or working memory tasks. Furthermore, controlling for subjective feelings of stimulation did not significantly alter the correlation coefficients between average BAC and the differences in performance over the two conditions. This finding indicated that the association between alcohol and changes in performance was not strongly influenced, or altered, by feelings of subjective stimulation. Resultantly, subjective feelings of stimulation were related to alcohol consumption but were not influential in the changes in working memory task performance. Some research has studied the influence of subjective feelings of stimulation and sedation on working memory task performance. Their findings were mixed, but some

themes and processes emerging from these studies were valuable in understanding the present research findings.

There is some evidence that changes in performance on working memory tasks following alcohol consumption might not be affected by the participant's subjective feelings of stimulation (Cromer et al., 2010). However, other research suggested that subjective feelings of sedation are associated with more impulsive responding in working memory tasks resulting in performance deficits (Shannon, Staniforth, McNamara, Bernosky-Smith, & Liguori, 2011). Resultantly, the subjective sedative effects of alcohol may be as important as the stimulating effects. However, the present research data did not allow for a detailed exploration of this contention. Although a comparison of Cromer et al.'s (2010) and Shannon et al.'s (2011) studies suggested that only subjective feelings of sedation affect working memory task performance, other research has suggested that an expectancy of stimulation may be more important.

Some research has hypothesised that reported feelings of stimulation are the result of expectancy following alcohol consumption, rather than changes due to actual consumption or feelings of stimulation (Earleywine, 1994; Leonard & Blane, 1988). Research studies on the effects of subjective stimulation related to energy drink consumption demonstrated that executive task performance was reduced and participants reported inflated perceptions of ability. However, this was only true when participants expected to feel stimulated following consumption of the beverage (Marczinski, Fillmore, Henges, Ramsey, & Young, 2012). Although Marczinski et al.'s (2012) reports on expectancy of subjective stimulation were similar to those of Leonard and Blane's (1988), their research used a known stimulant rather than alcohol. However, neither sets of research were congruent with the present findings. Therefore, it is possible that other factors may have been important. Earleywine (1994) proposed that expectancy of a feeling of stimulation following alcohol consumption, rather than actual feelings of stimulation, contributed to changes in performance on working memory tests.

While the expectation of a stimulating effect of alcohol may change performance on working memory tasks, this effect may only be relevant to high risk groups such as heavy drinkers (Earleywine, 1994). For the present research sample, no significant relationship between subjective feelings of stimulation and general alcohol consumption levels, or binge drinking episodes, was found. Resultantly, based on Earleywine's (1994) hypothesis, it was unlikely that any category of the present research's participants were more prone to expect subjective feelings of stimulation. Therefore, the absence of an expectation of feelings of

stimulation could have influenced the relative role of subjective stimulation in relation to alcohol consumption. Although subjective stimulation, participant age and average BAC were all interrelated, only participant age was influential in altering the relationship between average BAC and changes in performance during the experimental condition. However, it is also possible that inconsistent test-retest delay periods between the two assessments may have changed the nature of these relationships and effects.

Test-retest delay periods. Research has shown that performance on cognitive tasks can improve during the second administration of the test, even after lengthy delays (e.g. Bird, Papadopoulou, Ricciardelli, Rossor, & Cipolotti, 2004; Maylor et al., 1990). Although the present research did not make use of a set delay period, due to sampling and practical constraints, the minimum delay of four-weeks exceeded the three-week period recommended by Anastasi and Urbina (1997). Furthermore, the average delay period of ~87 days was considerably longer than the recommended period. However, in the present research, a slight statistical change in the models for the working memory subtests suggested that an influence of test-retest delay was possible. For the working memory subtests, these changes were not statistically significant, nor were the effect sizes substantial. On the other hand, the Dot Matrix subtest of Visuo-spatial Short-term Memory was significantly associated with test-retest delay periods. In this case, shorter delay periods were associated with deteriorations, rather than improvements, in performance. However, this phenomenon could not be accounted for by the present research data or available literature. Despite not being statistically significant, the influence of test-retest delay periods in the present research warranted brief theoretical discussion, particularly since an influence is commonly reported and has been considered in studies incorporating alcohol consumption (e.g. Bird et al., 2004; Cromer et al., 2010; Schweizer et al., 2006).

Repeated measurements of single tasks may enhance performance due to improved test-taking strategies, familiarity with testing environments, relaxation, reduction in anxiety over the outcomes of the second assessment, changes in attentional focus and other factors (Bird et al., 2004; Hausknecht, Halpert, Di Paolo & Moriarty-Gerrard, 2007; Lo et al., 2012; Maylor et al., 1990). Many of these factors were present in the current research but their influence may have been altered by alcohol consumption. Although repeated measures design studies which include an alcohol consumption component have not reported a relationship between BAC readings and short test-retest delay periods (e.g. Bartels, Wegrzyn, Wiedl, Ackermann, & Ehrenreich, 2010; Cromer et al., 2010), Schweizer et al. (2006) found differences in performance on semi-adaptable working memory tasks following alcohol consumption.

However, based on their analyses, Schweizer et al. (2006) declared these differences to be free of practice effects, even following repeated administration within a matter of days. Similarly, Jarosz et al. (2012) suggested that alcohol consumption negated practice effects on a verbal operations span task, even with short delays between administrations. The present research findings did not statistically support the presence of practice effects. However, the use of identical forms may have been important, whether or not practice effects were influential (e.g. Bird et al., 2004) or minimised by alcohol consumption (e.g. Jarosz et al., 2012).

Identical forms (administering the same test twice) (e.g. Cromer et al., 2010), rather than alternate forms (administering different tests measuring the same construct) or adaptable tasks (e.g. Schweizer et al., 2006), were used in the present research. There is evidence that practice effects are more prominent if identical forms are used over the repeated measurements (Bartels et al., 2010; Hausknecht et al., 2007), making the choice of this method a potential source of the improvements seen in performance on the working memory subtests during the experimental condition. However, in the present research all of the subtests represented identical forms over the two conditions but improvements in performance were only observed on the working memory processing tasks. Resultantly, if using identical forms was influential, the effect was isolated to the working memory subtests without being statistically significant. Although the present research findings do not support a statistically significant effect, some other research has suggested that working memory processing and executive functions are disproportionately affected by delay periods.

Some research has suggested that executive functions and working memory processing may improve during the second administration of a task but that rehearsal and recall functions remain unaffected (Jonides et al., 2008; Klapp, Marshburn, & Lester, 1983). These findings could be related to the less complex cognitive demands of short-term memory tasks or short-term memory capacity acting as a limiter of working memory without being directly influenced by practice effects (McEvoy, Smith, & Gevins, 1998). Therefore, assuming a minimal role of alcohol, the test-retest paradigm alone may also have been influential in the improvements in working memory processing during the second administration of the AWMA tasks. However, the statistical influence of variables such as average BAC and participant age was considerably stronger. Therefore, although test-retest delay periods may have theoretically influenced the outcome of the comparisons over the repeated measures, the associations were insufficient to draw firm conclusions from the data.

The inconsistent, extended delay periods used in the present research, along with the lower dose of alcohol, may have resulted in challenges in interpreting the data. Although some

research has shown practice effects may exist even after lengthy delays (e.g. Bird et al., 2004; Hausknecht et al., 2007), the literature has also supported a mitigating effect of alcohol consumption (e.g. Bartels et al., 2010; Cromer et al., 2010; Schweizer et al., 2006). Therefore, although the present findings suggested that practice effects on the working memory subtests may have been possible, it could not be definitively concluded that they were present. Furthermore, the lack of influence of test-retest delay periods on the association between average BAC and changes in performance suggested that the impact of delay periods was not associated with alcohol consumption. Therefore, based on the present research data, it was not possible to state that practice effects were statistically influential, or altered by the incorporation of alcohol consumption. A final covariate considered in this discussion is the RPM as a measure of non-verbal fluid intelligence.

The influence of the Raven's Progressive Matrices (Standard Form) on the visuo-spatial subtests. The Raven's Progressive Matrices (RPM) is a non-verbal measure of fluid intelligence known to be related to working memory (Ackerman et al., 2005; Colom et al., 2004; Raven et al., 2000). In the present research, the RPM was hypothesised to be a covariate which could affect the changes in performance on the AWMA subtests between the baseline and experimental conditions. However, the findings showed that the RPM was not influential in altering the statistics of difference over the two measurement conditions, except for a moderate influence on the Odd-one-out subtest measuring Visuo-spatial Working Memory. Although the dual requirements of pattern recognition were present, the mechanisms resulting in this finding were not identifiable. Nonetheless associations between the RPM and the baseline scores on the AWMA should be discussed since a significant relationship was only present for the visuo-spatial subtests. This type of split between the verbal and visuo-spatial domains has also been described in other research for both short-term and working memory task performance (Cocchini, Logie, Della Sala, MacPherson, & Baddeley, 2002; Gilhooly, Wynn, Phillips, Logie, & Della Sala, 2002; Logie, 2011) and is congruent with both the hypothesised structure of the AWMA (Alloway, 2007) and the Baddeley and Hitch (1974, 1983) modal model on which the test is based. Although some research supports the split between the visuo-spatial and verbal domains, the findings from the literature regarding the relationship between fluid intelligence and each domain are mixed.

Research on the relationship between fluid intelligence and working memory has reported general associations in both the visuo-spatial and verbal domains (e.g. Ackerman et al., 2005; Colom et al., 2004; Engel de Abreu, Conway, & Gathercole, 2010). However, the strength of a hypothesised general relationship between different tests of fluid intelligence and

working memory in the different domains is debatable (cf. Conway et al., 2002; Duff, Schoenberg, Scott, & Adams, 2005; W. Schneider & Niklas, 2017). Despite other findings of a general relationship, the present study's findings only supported a relationship between the RPM measurements of fluid intelligence and visuo-spatial short-term and working memory. This domain-specific relationship between non-verbal measures of fluid intelligence and visuo-spatial working memory tasks has also been reported in other research.

Both Gray et al. (2017) and Giofré, Mammarella and Cornoldi (2013) demonstrated that non-verbal fluid intelligence measures were strongly related to visuo-spatial working memory tasks but less so to verbal working memory tasks. The present study's findings were congruent with those of Gilhooly et al. (2002), who also found a significant relationship between the RPM and only visuo-spatial memory tasks. Conway et al. (2002) concurred that the RPM is strongly related to visuo-spatial working memory tasks but reported significant, albeit weaker, relationships with verbal domain tasks. However, the type of working memory task used differed between these studies and could have influenced the findings. Therefore, it is possible that both task type and domain play a role in the relationship between fluid intelligence and short-term or working memory, including executive functions as a separate entity (cf. Giofré et al., 2013). The present research made use of multiple task types and, therefore, the short-term and working memory tasks could be considered separately. Resultantly, a clear relationship between the RPM and the visuo-spatial domain, but not the verbal domain, emerged. This relationship was evident for both the short-term memory and working memory processing tasks.

The present findings showed similar strengths of relationship between the RPM and both the short-term and working memory visuo-spatial subtests. Contrary to this finding, some other research has shown that non-verbal measures of fluid intelligence might not be as strongly related to short-term memory tasks as it is to working memory tasks (Ackerman et al., 2005; Kane, Hambrick, & Conway, 2005). However, Engle, Tuholski, Laughlin and Conway (1999) also argued for a strong overlap between the requirements of working memory tasks and short-term memory tasks. This overlap was present for the AWMA subtests as a relationship with the RPM was observed for both the short-term memory and working memory processing tasks. The present findings may be congruent with Engle et al.'s (1999) proposition of an overlap between short-term and working memory task performance, or could indicate a general shared variance unique to the visuo-spatial domain regardless of the type of task. Therefore, the findings of the present research showed a clear link between the RPM as a non-verbal measure of fluid intelligence and the visuo-spatial domain measured by the AWMA short-term and

working memory subtests. However, it was unclear whether this relationship was representative of a link between fluid intelligence and working memory or the result of shared variance between short-term and working memory processing tasks within the visuo-spatial domain. Although the RPM was shown to have a domain-specific relationship with the AWMA visuo-spatial subtests, the test was not influential in the changes observed over the repeated measures on the AWMA and did not alter the relationship between average BAC and changes in performance under the experimental condition.

The findings of the present research were both congruent and incongruent with other studies. Factors such as stimulus representation, attentional activation, self-evaluation and metacognition may have been broadly influenced by alcohol consumption and could be related to the direction of the observed changes in performance during the experimental condition. Feelings of stimulation following alcohol consumption were present and were related to average BAC, but controlling for this factor did not influence the statistical models. In contrast, participant age may have played a role in how alcohol consumption changed performance on the AWMA subtests. However, the mechanisms of this influence were unclear and developing a theoretical explanation was challenging as the present findings deviated from those of the limited literature on the topic. Test-retest delay may have played a small role in the changes in performance observed. The findings suggested that shorter delay periods could have been associated with positive changes in performance during the second administration of the tests. Lastly, although the RPM was not influential in the observed changes following alcohol consumption, it was of interest that it was only related to the AWMA visuo-spatial subtests. The discussion of the present findings was valuable in understanding the complex influence of alcohol consumption on short-term and working memory tasks. In particular, underlying functions inherent in task performance may be differentially influenced by alcohol. However, the research was subject to several limitations which may have contributed to the incongruences observed.

Strengths and Limitations

Research Design

Sample characteristics. A strength of the present research was the rigorous sampling criteria implemented. Extraneous variance may be introduced from a variety of sources in experimental research, including sample characteristics. When conducting experimental research, homogenous samples can lend strength to the findings by reducing the variability of

within-person characteristics (Hair et al., 1987; Rosenthal & Rosnow, 2008). Therefore, the consideration of practical aspects of the research, potential outcomes and the theoretical orientation used is important in selecting sample requirements. This was considered particularly important in the current research due to the wide variety of potential physiological responses to alcohol consumption. The nature of the response, including rapidity of absorption, are also partially dependent on various demographic factors such as age or drinking habits (Davies, 2003). Although homogenous samples lack generalisability, for experimental research they can provide a better test of theory under controlled conditions, especially if random, representative samples are not obtainable or practicable (Howitt & Cramer, 2011; Rosenthal & Rosnow, 2008). In addition to stringent sampling criteria, the present research also considered the influences of within-person covariates as part of the statistical models. None of the published research reviewed included physiological or lifestyle related comparisons and control checks prior to experimental study or as part of the statistical analyses.

In the present research a variety of personal physiological and lifestyle information was gathered both as part of the screening process and for control purposes. Although the age range of participants was restricted, age was a covariate and potential source of influence. The consideration of participant age was helpful in interrogating the possible influence of the limited range of ages free of the influence of advanced age on working memory but did reduce the generalisability of the findings. Truncated age ranges such as that in the present research, and the 21 to 30 years restriction in Saults et al.'s (2007) research, may be insufficient to account for the subtle influences of age on alcohol consumption and/or related to changes to memory. The present research also included statistical comparisons to assess the possibility of undue variance from physiological factors such as weight and body mass index, as well as general drinking habits and lifestyle factors. Rather than statistically controlling for, or comparison checking, drinking habits, Saults et al. (2007) adjusted the dosages of alcohol administered according to participants' typical drinking patterns to account for habituation. George et al. (2005) controlled for these influences by restricting the sample to social drinkers although the inclusion criteria were not specified. However, none of the reviewed studies considered the potential influence of drinking habits aside from excluding excessive drinkers from the sample. In contrast, the present research rather conducted statistical comparisons to ensure identification of demographic, physiological or lifestyle variables which may have required statistical control given the experimental nature of the research. Overall, it is likely that the strict sampling requirements strengthened the integrity of the present research particularly since other studies have attempted random sampling with less stringent criteria.

However, practical considerations, along with the strict sampling criteria, resulted in a small sample size.

Other research has included both male and female participants with broader age ranges and a wider variety of physiological and lifestyle characteristics but failed to achieve sample sizes greater than 120 persons for group comparison purposes (e.g. Finn et al., 1999; Lyvers & Maltzman, 1991; Weissenborn & Duka, 2003). Studies with smaller sample sizes of between 10 and 20 have reported similar findings to those with larger sample sizes, even when using group comparisons methods (e.g. Cromer et al., 2010; Montgomery et al., 2011; Pualus et al., 2006). The sample size in the present research was within this second bracket, resulting in a variety of potential issues often associated with a smaller sample size. The most common issue is a lack of variability within the sample, leading to an insufficient range and dispersion of values which may result in inaccurate statistics, particularly if parametric statistics are utilised (Rosenthal & Rosnow, 2008). However, methods to mitigate the influence of small sample sizes, and to check the integrity of the statistics obtained should procedures such as bootstrapping not be possible, can be implemented.

One method employed to mitigate issues of small sample sizes is the use of bootstrapping based on the Monte Carlo simulation method of multiple samples within certain parameters to simulate a larger sample size (Hoyle, 1999). In this case, the present research implemented this protocol for the basic comparisons to $B = 1000$ permutations finding low levels of bias and similar statistical results to the repeated measures analysis of variance. Unfortunately, statistical analyses do not permit bootstrapping in some cases and, therefore, not all analyses could be subjected to this protocol. Hoyle (1999), as well as Rosenthal and Rosnow (2008), caution that bootstrapping may not always produce reliable findings due to the resampling method being dependent on the range of scores present in the original sample. Therefore, the mentioned range and dispersion values of the scores in this research are of importance in interpreting the findings. However, the data characteristics, bias check and comparison of the findings suggests that, despite the small sample size, the data obtained were sufficient for the analyses conducted and the bootstrapping comparisons were likely to have served their purpose. Despite utilising bootstrapping as cross-referencing to assess the initial suitability of the statistics, the use of small samples can be challenging in calculating both effect sizes and probability values due to the high potential for error variance (Howitt & Cramer, 2011). This is particularly true of between-group designs. The present research dealt with this limitation by using a test-retest, or within-persons, design whilst accounting for covariates known to introduce unwanted variance.

Repeated measures design. In the present research, the use of a within-persons, rather than a between-groups, design assisted in reducing the introduction of error variance due to between-persons factors. Furthermore, this design helped alleviate issues of sample size and make the attainment of a homogenous sample more feasible. The choice of a repeated measures design was made due to concerns over sample size during the planning phase, as well as to address weaknesses present in other published research which have failed to utilise identical measures over repeated instances. The failure to utilise repeated measures has left other published research subject to error variance introduced by using separate groups. As an alternative, Schweizer et al. (2006) used repeated measures of working memory on different tests measuring similar constructs. However, this method is subject to the potential for a lack of equivalence between task types, as well as the same familiarity effects that identical forms repeated measures designs are subject to. Claus and Hendershot (2015) used identical forms for their repeated measures study of the impact of alcohol on a working memory task. However, the short delay of only a few days was probably insufficient to mitigate practice effects although the intention was the measurement of neurological responses, minimising this concern. Nonetheless, given the few studies that used such a design, generalisability of within-persons research findings to the present research's methods is not fully possible. In both cases, the attempts to avoid the introduction of unwanted variance from between-group comparisons methods was replaced with other sources of error variance. However, the appropriate use of repeated measures designs can alleviate several between-group issues, particularly if identical forms are used to measure the construct of interest, as well as addressing issues around sample size.

Sample size, homogeneity of sample characteristics and extraneous between group variance are not uncommon challenges in psychological and behavioural research. These factors require special attention in experimental designs when selecting appropriate statistical analyses (Hoyle, 1999; Rosenthal & Rosnow, 2008). Rosenthal and Rosnow (2008) point out that repeated measures designs can mitigate the unreliability introduced by small samples since a correlational procedure is used across the conditions, resulting in increased precision of measurement. Furthermore, Hoyle (1999) notes that one of the most effective methods of increasing power in small sample research designs is the employment of a within-subjects, or repeated measures, method. The correlational nature of the within-person design results in an estimate of the contribution of the variance introduced by the experimental condition, whilst retaining a set level of variance for the within-persons factor. Resultantly, error variance is explicable in terms of individual difference which is automatically controlled for along with

extraneous error (Blackwell, de Leon, & Miller, 2006; Howitt & Cramer, 2011). Although repeated measures designs are useful to reduce extraneous sample-based error variance, the dependency between the repeated measures within-subjects can influence the reliability of the statistical findings, particularly if residuals are not accounted for by the inclusion of a between-group comparison or control for known covariates (Bartko, 1966; Blackwell et al., 2006; Schwartz & Stone, 1998). This issue is most common when multiple repeated measures are analysed, particularly with small sample sizes, resulting in violations of the assumptions of sphericity when between-group comparisons are incorporated and an overfitting of the covariance matrices occurs (Blackwell et al., 2006). Because the present research made use of a simple repeated-measures protocol, issues of sphericity and multiple repeated measurements did not influence the reliability of the findings. Therefore, the simplicity of the design, assisted by strict sampling criteria, was useful in permitting accurate within-persons analyses.

An alternative method to the repeated measures design is matched sampling and the use of between-group comparisons. However, this method is complex and requires a sufficiently large sample size which is carefully screened and assessed prior to analysis using the comparison group (Quigley, 2003). In certain respects, the use of an experimental and control group may have been beneficial to the current research as the known influence of test-retest delay periods, practice effects and testing environment comfort would have been alleviated. However, considering the potential for differential and unmeasurable individual responses to alcohol consumption, even if physiological characteristics were matched across participants, a matched samples comparison would have been challenging, as well as creating difficulties in procuring a sufficiently sized sample. Therefore, although a matched pairs protocol utilising a control group may have alleviated some of the within-persons design challenges, other sources of error variance would have remained which could not be controlled for in the between-groups analysis of variance. These additional sources of variance were taken cognisance of in the repeated measures analysis of covariance models, presented in the results section of the present research (see Chapter 6), through deliberate statistical control. Consequently, the test-retest design reduced extraneous variance and the implementation of statistical control allowed for better exploration of factors associated with the influence of alcohol on the components of working memory. These analyses made the present research more comprehensive and analytically useful in furthering understandings of the impact of alcohol on the components of working memory although the strength of the conclusions drawn was reduced. The largest identified weakness of the repeated-measures design employed in the present research was the

possibility of practice effects due to the use of identical forms over repeated measures, particularly since the test-retest delay periods could not be standardised across participants.

An extended delay period was employed in the present research to control for practice effects, or familiarity, over the repeated measures using identical forms. In Chapter 6 ("Results"), the statistics showed that the test-retest delay periods did influence the outcome of the repeated measures comparisons. The consequences of this finding are considered in Chapter 7 ("Discussion and Findings"). Although the repeated measures design may have been successful in mitigating issues of sample size and between-group variance, the use of identical forms and practice effects may still have been problematic. However, the present research did assess the influence of test-retest delay periods, reducing error which would have been present and allowing for more a comprehensive analysis of the data. This contrasts with studies such as that of Schweizer et al. (2006), which utilised basic repeated measures with brief set delays over different forms, introduced other sources of variance due to differences in task types. Although test-retest delay was influential to the within-person comparisons, this choice of design also permitted the use of a smaller sample without unduly sacrificing the quality of the statistics, as confirmed by the bootstrapped *t*-test bias levels. Furthermore, although delay periods were not standardised, they were statistically controlled for, permitting a more thorough examination of the findings and reducing carry-over effects, a known weakness of within-person research designs (Hoyle, 1999). The unstandardised delay period also allowed for an opportunity to explore the influence of this variable on the outcome of the study. In the present research, a variety of other variables were also considered for their potential to influence the repeated measures findings. These covariates, as well as the nature of measurement of working memory, are considered in the next section.

Measured Variables

Short-term memory and working memory: Separate components and subtests. In contrast to most published studies dealing with the impact of alcohol on working memory (see Chapter 4), the present research measured the components of short-term memory and working memory by using twelve different tasks of these latent constructs. Although some researchers, such as Saults et al. (2007), attempted to isolate different memory processes such as verbal memory, most research has not clearly separated the components of working memory according to a modal model such as that of Baddeley and Hitch (1974, 1983), or fully accounted for interactions between memory processes such as those hypothesised by Cowan (1997, 1999). Both Baddeley and Hitch's (1974, 1983) component-based model and Cowan's (1997, 1999)

model focusing on embedded attentional functions are applicable, to some extent, to the findings of the present research. The measurement of short-term memory storage and working memory processing, utilising a wide variety of task types, led to differential findings in the present research suggesting that the consumption of a small dose of alcohol may impact each of these components differently. Therefore, studying the effects of alcohol on only one aspect of working memory, and generalising based on the findings as many researchers have done, is problematic. The separation provided an opportunity to specifically consider task types in relation to the experimental condition and covariates rather than drawing generalised conclusions regarding working memory as a global construct. Consequentially, it was found that covariates such as participant age appeared to impact the outcome of the repeated measures analyses. In the cited literature, the components of short-term memory and working memory have been confounded and potential confounding covariates have not been considered statistically as they were in the present research.

In the discussion of the findings of the present research, factors related to the consumption of alcohol were considered in depth. Furthermore, not all the components of short-term and working memory measured responded to the administration of alcohol in the same manner. Components such as Verbal Working Memory showed significant improvements and influences from specific covariates, such as participant age. On the other hand, changes in the Visuo-spatial Short-term Memory component showed less clarity in terms of direction and influence than those seen for the Verbal Working Memory subtests. It was apparent that short-term memory and working memory behaved differently over the two conditions, as did specific task types. For example, the Spatial Recall subtest was apparently unaffected by any of the variables whilst the Listening Recall subtest improved under the experimental condition and was influenced by participant age. Performance on the Verbal Short-term Memory subtests, on the other hand, generally deteriorated in score under the experimental condition and seemed to be more strongly influenced by average BAC values. The specificity of measurements permitted the consideration of the behaviour of the subtests under the experimental condition in terms of the influence of alcohol on specific components of memory. This included aspects such as the semantic connection between the phonological loop and long-term memory processes, attention and the distribution of attentional activation. These findings allowed for a unique consideration of the influence of alcohol, and covariates, on the experimental condition measurements in connection to the modal model of working memory as well as other process models of memory and connections to long-term memory functions. Prior studies have lacked a theoretical underpinning to their investigation of working

memory and have, therefore, not been able to consider these components separately, resulting in the drawing of broad conclusions without consideration for multiple impacts of alcohol and covariates.

Although these comparisons are useful in fully understanding the influence of alcohol, theoretical separation of components does limit the ecological validity of the research and perhaps disregards the potential for the impact of alcohol on memory as a comprehensive and complex process. The level of specificity of measurement due to task type may, therefore, have also constrained the full understanding of the impact of alcohol on working memory functions. The use of specific subtests created an artificial understanding of memory components which may not fully account for the interrelated complexity of the processes. As mentioned with regards to the differential changes on the different components of memory, the findings of the present research suggested a specific impact of covariates which also differed across the different memory tasks. This finding is important for further consideration of the components of memory and the influence of unknown factors which has been lacking in other published research.

Covariates. The findings of the present research showed that several covariates influenced the statistical outcomes of the models. The most notable influences were test-retest delay periods and participant age. Test-retest delay was dealt with earlier in this chapter due to its importance to the repeated-measures design of the present research. The Raven's Progressive Matrices (Standard Form) (RPM) was also found to be associated with changes over the two test conditions but only for the Visuo-spatial Working Memory subtests. Subjective intoxication, as measured by the derived "Stimulated" scale based on the early repeated measurements on the Brief Biphasic Alcohol Effects Scale (B-BAES) was not found to be highly influential. These covariates, as well as the initial comparisons excluding demographic and lifestyle variables as a source of variance, required statistical considerations. Control for these influences has not generally been conducted from a statistical perspective in other published research.

A few studies attempted to control for some covariation through procedural alterations, for example. Studies have restricted sample characteristics during group comparisons (e.g. Acheson et al., 1998), utilised larger samples with similar drinking habits to reduce error variance from that source (e.g. Weissenborn & Duka, 2003) or administered alcohol in relation to physiological factors, such as body weight and average drinking levels (e.g. Saults et al., 2007). Paulus et al. (2006), Saults et al. (2007) and Weissenborn and Duka (2003) restricted age criteria to similar ranges as the present research, limited drinking habits (social drinkers)

and administered alcohol per kilogram body weight rather than a set dosage. However, these researchers failed to statistically compare the influence of these factors on breath alcohol measurements or to account for variance introduced in the statistical comparisons.

Those studies which considered the influence of potential covariates on the outcome relied on the comparisons of groups, bolstered by larger sample sizes, resulting in an absence of consideration of body weight and type, exercise levels, specific age of participants and baseline functioning. The present research considered these factors as preliminary variables, thereby ensuring an absence of any statistically noteworthy impact on either short-term memory or working memory function, or average breath alcohol concentration readings which were deemed important to the research. Although these factors have been considered methodologically in other research, fine-tuned statistical control and analysis within a homogenous sample has been lacking, resulting in the potential for error variance in group comparisons or repeated measures designs. However, given the small sample size of the present research, the comparisons conducted may not have been sufficient to eliminate the possibility of error variance caused by these factors.

Alcohol Administration, Absorption and the Measurement of Intoxication

The most prominent limitation in the present research, existing partially due to ethical reasons, was the use of a small, standard dosage of alcohol (13.6g by volume). However, in other respects, the dosage created a unique opportunity for the assessment of the impact of alcohol on memory functions in a manner not previously undertaken. Comparable research has made use of higher alcohol dosages usually relevant to body weight and drinking habits of the participants (e.g. Claus & Hendershot, 2015; Saults et al., 2007; Weissenborn & Duka, 2003). Other studies have focused on achieving specific peak breath alcohol concentrations of a specific value (e.g. Lyvers & Maltzman, 1991). Lechner et al. (2015) made use of a dosage of 0.4g/kg body mass as a low dosage condition which produced different findings, notably an absence of impairment, to that of a moderate dose condition comparable to Weissenborn and Duka's (2003) 0.8g/kg administration. In both cases, the calculated dosages were considerably higher than that administered in the present research, perhaps contributing to the differences in the research findings.

Hoffman et al. (2015) concurred with Lechner et al. (2005) that subclinical doses may not produce significant impairments in comparison to high dosages of approximately four standard drinks, such as that used by Casbon et al. (2003). Resultantly, although the very low dose of alcohol was of interest in terms of the ecological validity of the study, the changes in

short-term memory and working memory function produced may not have been equivalent to those present under higher dosage conditions. Furthermore, the use of a standard dose as opposed to a measured dose may have influenced the findings despite attempts to control for sample characteristics and statistical checks between variables such as participant weight and the BAC readings produced. The studies mentioned have generally attempted to equate dosage to body weight and drinking habits by administering alcohol on grams of ethanol per kilogram of body weight formulae to produce target BAC levels in the participants. This method increases the standardisation component of the research studies, particularly important for between-group comparisons.

The intention of weight-dependent or peak BAC related dosages is the assessment of a true impact of alcohol in a standardised environment, free of physiological and metabolic factors which may influence outcomes. Participant weight, height and general drinking habits, also considered in the present research, are generally of primary concern when calculating required dosages. However, in the present research, average BAC readings due to acute alcohol consumption were not found to be dependent on physiological or lifestyle factors, except participant age. Therefore, the potential for error variance was lower than expected. Nonetheless, the use of a small, standard, dose of alcohol did result in between-person variability in readings on the blood alcohol concentration (BAC) curve which may have impacted the findings and the activity of this variable in the repeated measures analysis of covariance models. Due to the low dosage of alcohol, participants returned to a 0.00 BAC reading rapidly, the effect of which on performance later in the AWMA assessment, despite the randomisation protocol, was unknown.

Breath alcohol concentration readings may not necessarily be indicative of an influence of alcohol on performance. Cromer et al. (2010) reported that working memory remained impaired even once participants no longer reported feeling inebriated. Other research has suggested that alcohol may still impact performance on a variety of functional tasks after BAC levels have returned to zero (Zakhari, 2006). This supposition is linked to absorption time, where full absorption times may be 30-90 minutes with continued changes in performance on various tasks, including neurological responses (Dubowski, 1985; Zakhari, 2006). This contrasts with the standard 10-15 minutes post-consumption delay used in most cited research, including the present study. However, extensive delay periods following consumption create challenges in measuring intoxication and selecting peak periods for performance change. In the present research, this issue was compounded by the lengthy assessment times even though these did not appear to be associated with changes in the outcome variables or other factors.

However, due to the lengthy time frames, average BAC readings quickly returned to zero, potentially resulting in these values being an unreliable linear covariate for the purposes of statistical analysis.

Breath alcohol concentrations are the most commonly utilised method of assessing intoxication as blood alcohol readings are frequently impractical. The peak absorption periods, and associated changes in performance, have large ranges and are subject to wide individual variations (Bailey, Bartholow, Saults, & Lust, 2014) making objective measurement of intoxication almost impossible. Therefore, the small dose of alcohol and permitted absorption time used in the present research may have elicited BAC readings which were not an accurate reflection of intoxication levels. The same may be true of other research in this area despite the attempts at standardised levels of intoxication which, nonetheless, may still have been subject to individual variations in performance outcomes. Although the BAC levels recorded in the present research may not have been equal to those resulting from the higher doses used in the literature cited, study of subclinical dosages still provides valuable information. Given the differential performance of the different memory components under the experimental condition, it is apparent that even a low dose of alcohol may have influenced working memory performance. However, these changes are not necessarily comparable to those of other research given the different dosage level. Despite consideration of average BAC as a covariate within the repeated measures models, the basic quantity of the dose, and resultant BAC readings, may have impacted the nature of the findings.

The present research made use of progressive measurements of BAC levels to accurately account for changes in the BAC curve over time. Therefore, rather than achieving a peak dosage for comparison to a control group, or other dosage groups (e.g. Grattan-Miscio & Vogel-Sprott, 2005), an average reading was recorded. Coupled with the randomisation of the experimental condition subtest order, the use of progressive readings with an average calculation mitigated challenges in controlling for changes over the BAC curve where different peaks have been linked to differential effects of alcohol consumption (e.g. Saults et al., 2007; Schweizer et al., 2006). However, due to the combination of the low dosage of alcohol, averaging of readings and sensitivity of the equipment to two decimal places, tied ranks were present. Additionally, the lengthy assessment time frame may have impacted the findings. Resultantly, although a consistent curve of BAC readings was present, the average readings lacked the ideal range and dispersion of scores. Although research such as that of Schweizer et al. (2006) has considered positioning on the BAC curve, no published research located appears

to have incorporated the use of specific BAC reading values as a covariate for comparative purposes in modelling over repeated measures.

Conclusion and Recommendations

This research study examined the influence of a low dose of alcohol on the different components of working memory as measured by the twelve subtests of the Automated Working Memory assessment. The AWMA provided three measurements each of Verbal Short-term Memory, Verbal Working Memory, Visuo-spatial Short-term Memory and Visuo-spatial Working Memory. The present study employed a repeated measures (test-retest) design with an extensive, measured, delay period with the intention of avoiding practice effects. Under the experimental condition, a low dose of alcohol was administered, multiple breath alcohol readings were taken and subjective intoxication was measured on the Brief Biphasic Alcohol Effects Scale at multiple points. Furthermore, important variables such as the Raven's Progressive Matrices (Standard Form), participant age, exercise levels, weight and body mass index were considered for their potential as covariates.

The findings of the present research suggested that, in most cases, performance on the various AWMA subtests changed under the experimental condition. The subtests measuring short-term memory components tended to show fractional improvements (close to zero) under the experimental condition or deteriorations in performance. Meanwhile, the subtests measuring working memory showed improvements under the experimental condition. Although factors such as weight and body mass index did not seem to be related to the average breath alcohol concentrations (BAC) produced, the covariates participant age and subjective stimulation were related to average BAC readings. Furthermore, the RPM was associated with the Visuo-spatial Short-term Memory and Visuo-spatial Working Memory subtests although it was not influential in terms of differences over the two conditions except in the case of the Odd-one-out subtest. However, test-retest delay periods, resulting from the repeated measures design, were consistently influential. Rather than single comparison models, the present research made use of repeated measures analysis of (co)variance models and the effect sizes and associated statistics were compared dependent upon the construction of the model. These findings revealed several important points which should also be considered in future research.

The repeated measures, within-persons, design employed in the present research was quite unique and presented an opportunity for understanding the influence of alcohol without hindrance from between-persons factors in a group comparisons design. However, test-retest delay periods remained influential when the various repeated measures analysis of covariance

models and associated covariate interactions were compared. Therefore, despite efforts at eliminating practice effects, test-retest delay impacted performance during the second administration of the assessment. However, further extensions of delay periods may have resulted in other changes to working memory functions which could have also influenced changes over the two conditions. This issue creates a conundrum in designing accurate research to assess the influence of alcohol with both within-persons and between-groups designs presenting their own challenges. As was conducted in the present research, specific control for covariates is a useful procedure in mitigating some of the challenges inherent in alcohol-related research designs and should be explored in further research under more stringent conditions.

The present research concluded that certain covariates were influential in altering the model statistics over and above, or in conjunction with, the influence of acute alcohol consumption. Some components of the memory model were more strongly influenced than others where the Verbal Short-term Memory AWMA subtests were more susceptible to influences from age and average BAC readings while the Verbal Working Memory subtests were more susceptible to influences from test-retest delay and age only. Control for these covariates from a statistical standpoint has not been implemented in the reviewed research, making these issues an important avenue for further exploration. Despite the restrictions on sampling characteristics, specific ages remained influential. Since little research exists in this area, with most studies considering older participants or younger participants as groups, the finer influences of participant age in relation to alcohol consumption and working memory performance require further exploration. Based on the present research's findings, it is not possible to isolate the influence of participant age free of the influence of acute alcohol consumption or other factors. Aside from generalised influences from covariates, the different components of working memory also appeared to be subject to different changes in performance under the experimental condition.

The Verbal Working Memory subtests and Visuo-spatial Working Memory subtests, excepting Spatial Recall, improved under the experimental condition. Comparisons of the various models revealed that participant age and test-retest delay were both influential in the repeated measures differences. Linearly, average BAC values did not always appear to be associated with the differences. However, the relationship between BAC readings and performance-altering impacts of alcohol, along with absorption times, does not necessarily preclude an influence of this variable. The improvements seen in the Verbal Working Memory subtests, as well as the Visuo-spatial Working Memory subtests, may have been due to a variety of factors. These included diffuse attentional activation following alcohol consumption, a

reversion to global processing with challenges in focusing specific attention, increased relaxation and decreased inhibitions. These factors may also have been influential in the reductions in performance seen on the Verbal Short-term Memory subtests under the experimental condition. In these cases, average BAC readings did appear to be linearly associated with differences over the repeated measures, suggesting the possibility that storage and rehearsal functions were negatively impacted following alcohol consumption. The differential influence of alcohol consumption over the different components of memory requires further investigation, particularly regarding changes in attention and global cognitive function which may have been facilitated by changes due to a low dose of alcohol. Furthermore, although linear measurement of average BAC, or the identification of peak BAC values, is useful for comparative purposes, some research cited has suggested that these readings may not truly reflect the influence of alcohol on performance. Issues surrounding the impact of alcohol, both in relation to the BAC readings produced and as a general effect, should be given further attention, particularly utilising extended time-frames. In relation to this point, the potentially unique short-term and long-term effects of different dosages require further consideration.

Although the administration of a standard dosage rather than weight-dependent dosage is not necessarily ideal, the preliminary analyses in the present research did not suggest that extraneous variance was introduced by physiological factors of the participants. Most of the published research focused on assessing a clear effect of alcohol consumption. However, when these results are compared to the findings of the present study, these results, and some from other published research, suggest that very low alcohol doses may have different effects to higher doses. Consequently, the subtle impact of low doses of alcohol requires further investigation. Further review of the literature in relation to the findings of the present research suggested that alcohol doses may result in different patterns of cortical activation, attentional diffusion, states of relaxation or other factors. These changes may not necessarily be directly correlated to formal measurements of breath, or blood, alcohol concentrations. As a result, more accurate measurement techniques are required for the specific understanding of alcohol dosages as well as alterations in study design to account for residual influences. Issues of peak absorption time, which is subject to individual variations, also require consideration and may have been influential in the results seen for the present research. These issues require further investigation utilising carefully designed studies.

The present research employed stringent sampling requirements, a test-retest repeated measures design and statistical control for physiological and demographic covariates.

Furthermore, a very low dose of alcohol was administered resulting in a potential unique impact which was progressively measured along with levels of subjective intoxication. Sources of covariance, such as participant age, proved influential and, despite the extensive delay between test sessions, test-retest delay periods were potentially problematic. Nonetheless, changes in performance under the experimental condition were apparent in almost all the AWMA subtests with improvements being noted for the working memory subtests and deteriorations in the short-term memory performance factors. It is quite possible that these changes were at least partially linked to the consumption of alcohol. However, covariates such as test-retest delay and participant age also appeared to impact the findings to some extent. The findings suggested that different components controlled had different influences dependent on the specific subtests examined and that further research ameliorating the weaknesses identified in the present research and implementing more extensive control for known covariates is required.

Aside from the theoretical implications of the present findings, certain practical recommendations can be considered. In the present research, younger participants tended to record higher BAC levels and were more prone to deficits. This was notable given that the participants in the present study exceeded the legal alcohol consumption age by three years or more. This finding would imply that although participants were deemed legally capable of dealing with the consequences of alcohol consumption, a disproportionate influence of consumption may still have been present when compared to older individuals. Furthermore, although stimulus evaluation with concomitant recall were shown to be improved under the influence of acute alcohol consumption in the present research, global processing may still be subject to deficits. Therefore, executive-function based activities, such as driving, or other activities requiring focused attention and complex evaluation (e.g. Pihl, Paylan, Gentes-Hawn, & Hoaken, 2003; Redick, et al., 2012; Steele & Josephs, 1990), may remain inhibited even at low BAC levels. This would apply to all individuals but particularly younger persons who are known to be more prone to negative legal consequences following excessive alcohol consumption (Setlalentoa et al., 2010). Regardless of the direction of influence, the present study did confirm that even a low dose of alcohol producing BAC levels at, or below, the legal driving threshold influenced performance on memory tasks. This finding would imply that a range of activities may be influenced even at these levels. Furthermore, low doses of alcohol may still result in deficits in decision-making or action, particularly if deliberate attention or short-term recall of recent events is required. Although specific behaviours are likely to be influenced by acute consumption in a variety of ways, the present findings may also have implications for preventative measures.

In terms of attempting to reduce the negative consequences of alcohol consumption, the present findings provided valuable information regarding known consequences of consumption and related attempts at intervention. Various intervention foci are described in documents such as the Western Cape Government Strategic Programmes Branch's (2017) policy on the reduction of alcohol-related harm in that province. Resultantly, although stimulus evaluation was not found to be impaired, general awareness campaigns may require processing which is too global to be positively affected and the provision of more specific, direct information may be required. This would have wide reaching implications regarding the effectiveness of legislation banning the advertising of alcohol and similar preventative measures. Furthermore, the inability to effectively utilise focused attentional processes, particularly in conjunction with long-term memory stores, may result in a disregard for known information regarding the consequences of excessive consumption. This would be likely to reduce the effectiveness of awareness campaigns. The same is applicable in terms of individuals known to be susceptible to excessive consumption should decision-making processes be altered following the passing of a specific BAC threshold. Overall, avoidance of the negative consequences of alcohol consumption would require interventions above and beyond immediate negative consequences or broad informational campaigns which may not be retained following consumption even at a low dosage.

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Appendix A

R14/49 Ms Ingrid Opperman

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M150267

NAME: (Principal Investigator)	Ms Ingrid Opperman
DEPARTMENT:	School of Human Community Development
PROJECT TITLE:	The Impact of Alcohol on the Different Components of Working Memory
DATE CONSIDERED:	27/02/2015
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Prof Kate Cockcroft
APPROVED BY:	Professor P Cleaton- ones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	29/06/2015

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and ONE COPY returned to the Secretary in Room 10004, 10th floor, Senate House, University.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. I agree to submit a yearly progress report.

Principal Investigator Signature

15 July 2015
Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix B

Tests of Normality of the BAC measurement points

Table B1

Kolmogorov-Smirnov and Shapiro-Wilk Tests of Normality of the Individual Breath Alcohol Concentration Measurement Points (n = 16)

	Kolmogorov-Smirnov		*Shapiro-Wilk*	
	Statistic	*p*	*Statistic*	*p*
BAC Subtest 1	0.137	.200	0.942	.374
BAC Subtest 2	0.207	.066	0.883	.043*
BAC Subtest 3	0.173	.200	0.863	.021*
BAC Subtest 4	0.209	.061	0.834	.008**
BAC Subtest 5	0.261	.005**	0.842	.011*
BAC Subtest 6	0.320	.000**	0.783	.002**
BAC Subtest 7	0.298	.001**	0.794	.002**
BAC Subtest 8	0.296	.001**	0.804	.003**
BAC Subtest 9	0.344	.000**	0.752	.001**
BAC Subtest 10	0.384	.000**	0.703	.000**
BAC Subtest 11	0.368	.000**	0.707	.000**
BAC Subtest 12	0.414	.000**	0.644	.000**
BAC Post-test	0.448	.000**	0.587	.000**
Average BAC	0.241	.014*	0.869	.026*

* Significant at the 5% level

**Significant at the 1% level

Appendix C

Baseline and Experimental Internal Correlations Between the Automated Working Memory Assessment Subtests

The correlation coefficients for the Verbal Short-term Memory component of the AWMA were conducted inclusive of bias corrected accelerated (BCa) estimates (B = 1000) and are presented in Table C1. Given the nature of the different components of the assessment, each subtest was considered in relation to itself and its composite companions. This was done to examine the combination structure of each of the subtests within each composite of the AWMA instrument.

Table C1

Baseline and Experimental Interrelated Correlation Coefficients: Verbal Short-term Memory (n = 16)

		Baseline Measurement			*Experimental Measurement*		
		Digit Recall	*Word Recall*	*Nonword Recall*	*Digit Recall*	*Word Recall*	*Nonword Recall*
Baseline Digit Recall	*r*	1	.702**	.190	.843**	.854**	.262
	p		.002	.481	.000	.000	.326
	BCa Bias	0	-.033	-.020	-.026	-.036	.025
Baseline Word Recall	*r*	.702**	1	.412	.602*	.856**	.400
	p	.002		.113	.014	.000	.125
	BCa Bias	-.033	0	-.034	-.045	-.015	-.004
Baseline Nonword Recall	*r*	.190	.412	1	.040	.330	.393
	p	.481	.113		.883	.211	.132
	BCa Bias	-.020	-.034	0	-.033	-.025	-.036
Experimental Digit Recall	*r*	.843**	.602*	.040	1	.636**	.402
	p	.000	.014	.883		.008	.123
	BCa Bias	-.026	-.045	-.033	0	-.060	.014
Experimental Word Recall	*r*	.854**	.856**	.330	.636**	1	.366
	p	.000	.000	.211	.008		.163
	BCa Bias	-.036	-.015	-.025	-.060	0	.009
Experimental Nonword Recall	*r*	.262	.400	.393	.402	.366	1
	p	.326	.125	.132	.123	.163	
	BCa Bias	.025	-.004	-.036	.014	.009	0

* Significant at the 5% level
** Significant at the 1% level

Low levels of bias were present based on the bootstrapping procedure. In most cases, the Pearson's r values fell centrally within the upper and lower 95% bootstrapped (B = 1000) bounds. Most of the correlation coefficients were statistically significant at either the 5% or 1% level, excepting Nonword Recall (r = .393, p = .132) for which only a weak relationship between the two sets of measures was apparent. The Digit Recall baseline assessment was

significantly correlated with the baseline assessments of Word Recall (r = .702, p = .002). The correlation between the baseline Digit Recall assessment score and the baseline Nonword Recall assessment score was not statistically significant (r = .190, p = .481). The weaker association was also apparent for the baseline Nonword Recall correlation with Word Recall (r = .412, p = .113). When the sets of experimental assessments were examined, similar findings were calculated, particularly the lack of correlation between the subtests and Nonword Recall.

For the experimental assessments, the Digit Recall experimental score and Word Recall experimental score were moderately correlated (r = .636, p = .008). However, the Nonword Recall experimental score was not significantly correlated with either the Digit Recall experimental score (r = .402, p = .123), or the Word Recall experimental score (r = .366, p = .163). The weaker correlations between the Nonword Recall scores in both the baseline and experimental conditions implied some difference in measurement within each set of assessments.

The Digit Recall baseline assessment was significantly correlated with its experimental counterpart (r = .843, p = .000). The repeated measures for Word Recall were significantly correlated (r = .856, p = .000). However, the Nonword Recall baseline subtest was not significantly correlated with its experimental counterpart (r = .393, p = .132). The correlational findings suggest a consistency of measurement without collinearity concerns. However, poor associations between the baseline and experimental values for Nonword Recall raise questions surrounding the consistency of this subtest, particularly considering the poor association with the other Verbal Short-term Memory subtest scores, although the deviation may have been due to the influences under the experimental condition. Correlational analyses were also conducted for the Verbal Working Memory subtest scores and are reported in Table C2. As was found for the Verbal Short-term Memory subtests' correlation coefficients, the values of BCa bootstrapping (B = 1000) were low.

Table C2

Baseline and Experimental Interrelated Correlation Coefficients: Verbal Working Memory (n = 16)

		Baseline Measurement			***Experimental Measurement***		
		Listening Recall	*Counting Recall*	*Backwards Digit*	*Listening Recall*	*Counting Recall*	*Backwards Digit*
Baseline Listening Recall	*r*	1	.513*	.603*	.701**	.661**	.594*
	p		.042	.013	.002	.005	.015
	BCa Bias	0	-.011	.003	.001	-.019	-.013
Baseline Counting Recall	*r*	.513*	1	.660**	.219	.547*	.452
	p	.042		.005	.415	.028	.079
	BCa Bias	-.011	0	-.002	-.019	-.016	-.016
Baseline Backwards Digit	*r*	.603*	.660**	1	.492	.470	.741**
	p	.013	.005		.053	.066	.001
	BCa Bias	.003	-.002	.000	-.002	.019	-.001
Experimental Listening Recall	*r*	.701**	.661**	.594*	1	.415	.545*
	p	.002	.005	.015		.110	.029
	BCa Bias	.001	-.019	-.013	0	-.009	-.007
Experimental Counting Recall	*r*	.219	.547*	.452	.415	1	.555*
	p	.415	.028	.079	.110		.026
	BCa Bias	-.019	-.016	-.016	-.009	0	.023
Experimental Backwards Digit	*r*	.492	.470	.741**	.545*	.555*	1
	p	.053	.066	.001	.029	.026	
	BCa Bias	-.002	.019	-.001	-.007	.023	0

* Significant at the 5% level

** Significant at the 1% level

The Listening Recall baseline subtest score was significantly correlated with the baseline Counting Recall subtest score (r = .513, p = .042) and the Backwards Digit baseline subtest score (r = .603, p = .013). The Backwards Digit subtest score at the baseline assessment was significantly associated with the Counting Recall subtest (r = .660, p = .005). During the experimental condition, statistically significant correlation coefficients were found between the various subtests. In comparison to the baseline correlation coefficients, correlation coefficient values weakened between the experimental Listening Recall subtest and experimental assessment of Counting Recall (r = .415, p = .110). On the experimental level, the correlation coefficient between the Listening Recall subtest and Backwards Digit recall subtest was also statistically significant (r = .545, p = .029), as was the correlation between the Counting Recall subtest score and Backwards Digit subtest score (r = .555, p = .026). To fully examine the AWMA assessment of verbal working memory, the baseline and experimental subtest scores were correlated as repeated measures.

The correlation coefficients between the baseline and experimental session scores of Verbal Working Memory were sufficient to assume relationship without being so excessive as

to raise concerns around collinearity. The correlation coefficients between the baseline and experimental items for the Verbal Working Memory subtests are noticeably lower than those shown in the Verbal Short-term Memory section.

The baseline to experimental correlation coefficient for the Listening Recall subtest was not excessively large (r = .701, p = .002), reducing concerns of collinearity and implying potential for external influence. The baseline Counting Recall subtest was significantly correlated as repeated measures (r = .547, p = .028). The Backwards Digit baseline score showed the strongest of the baseline to experimental administration correlations between the repeated measures (r = .741, p = .001). None of the Verbal Working Memory subtests showed sufficient repeated measures correlation coefficients to imply collinearity across the two conditions or a lack of influence under the experimental condition. These trends are valuable in understanding the separate component within each subtest under the baseline and experimental conditions, and useful for later analyses. Similar patterns were seen for the Visuo-spatial Short-term Memory separate baseline and experimental conditions analyses shown in Table C3.

Table C3

Baseline and Experimental Interrelated Correlation Coefficients: Visuo-spatial Short-term Memory (n = 16)

		Baseline Measurement			*Experimental Measurement*		
		Dots Recall	*Mazes Memory*	*Block Recall*	*Dots Recall*	*Mazes Memory*	*Block Recall*
Baseline Dots Recall	*r*	1	.486	.565*	.747**	.611*	.742**
	p		.056	.022	.001	.012	.001
	BCa Bias	0	-.007	-.028	-.005	-.031	-.014
Baseline Mazes Memory	*r*	.486	1	.191	.428	.439	.480
	p	.056		.478	.098	.089	.060
	BCa Bias	-.007	0	-.005	-.013	-.039	-.011
Baseline Block Recall	*r*	.565*	.191	1	.619*	.665**	.770**
	p	.022	.478		.010	.005	.000
	BCa Bias	-.028	-.005	0	.009	-.059	.000
Experimental Dots Recall	*r*	.747**	.428	.619*	1	.547*	.909**
	p	.001	.098	.010		.028	.000
	BCa Bias	-.005	-.013	.009	0	-.039	.001
Experimental Mazes Memory	*r*	.611*	.439	.665**	.547*	1	.597*
	p	.012	.089	.005	.028		.015
	BCa Bias	-.031	-.039	-.059	-.039	0	-.044
Experimental Block Recall	*r*	.742**	.480	.770**	.909**	.597*	1
	p	.001	.060	.000	.000	.015	
	BCa Bias	-.014	-.011	.000	.001	-.044	0

* Significant at the 5% level

** Significant at the 1 % level

Correlations between the Visuo-spatial Short-term Memory subtests for the baseline and experimental conditions separately were generally moderate to strong without being so high as to suggest undesirable levels of collinearity. Levels of bootstrapping bias were low. Correlations between the baseline subtest measurements were not as strong as expected, suggesting a lack of similarity in measurement. The baseline measurements of Dot Matrix and Mazes Memory were correlated at a medium strength but not statistically significant (r = .486, p = .056), as was the correlation coefficient between the Dot Matrix and Block Recall baseline subtests (r = .565, p = .022). The baseline measurements of Mazes Memory and Block Recall were weakly correlated (r = .191, p = .478). At the baseline level, it is evident that the Mazes Memory subtest and Block Recall subtest did not share many common factors.

The experimental measurements for Dot Matrix and Mazes Memory were moderately, but statistically significantly, correlated with one another (r = .547, p = .028). The experimental measure of Dot Matrix and experimental measurement for Block Recall were excessively correlated (r = .909, p = 000) implying collinear measurement under this condition only. Unlike for the baseline condition, the experimental measurement of Mazes Memory was moderately, and statistically significantly, correlated to the experimental measurement of Block Recall (r = .597, p = .015). This substantial alteration implies some changes in function between the baseline and experimental conditions in one, or both, of these subtests.

The baseline Dot Matrix score was significantly correlated with its matched experimental score (r = .747, p = .001). The baseline Mazes Memory was only moderately associated with the experimental measurement (r = .439, p = .089). The lack of strength of correlation between the two Mazes Memory assessments implies considerable change over the two conditions. The Block Recall baseline measurement and experimental measurement were strongly correlated (r = .770, p = .000), but collinearity was not a concern. For the Visuo-spatial Short-term Memory subtests, it is apparent that strong associations are present between the components, although the Mazes Memory subtest appears to operate somewhat differently. Furthermore, few concerns around collinearity arose based on the repeated measures correlation coefficients. Lastly, relationships between the Visuo-spatial Working Memory components were examined and are reflected in Table C4 reporting the baseline to baseline correlations, experimental to experimental correlations and baseline to experimental correlations.

Table C4

Baseline and Experimental Interrelated Correlation Coefficients: Visuo-spatial Working Memory (n = 16)

		Baseline Measurement			*Experimental Measurement*		
		Odd-One-Out	*Mister X*	*Spatial Recall*	*Odd-One-Out*	*Mister X*	*Spatial Recall*
Baseline Odd-One-Out	*r*	1	.625**	.741**	.750**	.492	.671**
	p		.010	.001	.001	.053	.004
	BCa Bias	0	-.006	-.013	-.006	.004	-.002
Baseline Mister X	*r*	.625**	1	.834**	.463	.750**	.759**
	p	.010		.000	.071	.001	.001
	BCa Bias	-.006	0	.000	.008	.002	.002
Baseline Spatial Recall	*r*	.741**	.834**	1	.730**	.814**	.903**
	p	.001	.000		.001	.000	.000
	BCa Bias	-.013	.000	0	-.006	-.001	.001
Experimental Odd-One-Out	*r*	.750**	.492	.671**	1	.642**	.652**
	p	.001	.053	.004		.007	.006
	BCa Bias	-.006	.004	-.002	0	.000	-.010
Experimental Mister X	*r*	.463	.750**	.759**	.642**	1	.806**
	p	.071	.001	.001	.007		.000
	BCa Bias	.008	.002	.002	.000	0	-.013
Experimental Spatial Recall	*r*	.730**	.814**	.903**	.652**	.806**	1
	p	.001	.000	.000	.006	.000	
	BCa Bias	-.006	-.001	.001	-.010	-.013	0

* Significant at the 5% level

** Significant at the 1% level

Bootstrap levels of bias for the correlations between the sets of baseline Visuo-spatial Working Memory scores were low with Pearson's *r* values falling quite centrally within the 95% lower and upper limits. The Odd-One-Out baseline subtest score was significantly correlated with the Mister X baseline subtest score ($r = .625$, $p = .010$) and Spatial Recall baseline subtest score ($r = .741$, $p = .001$). The correlations were statistically significant but not of a sufficient magnitude to suggest collinearity of measurements. A very large correlation coefficient was observed between the Mister X baseline subtest score and the Spatial Recall baseline subtest score ($r = .834$, $p = .000$). Although, moderate to strong correlation coefficients were observed between the various subtests in the baseline condition, Visuo-spatial Working Memory associations under the experimental condition were somewhat weaker.

Correlations between the sets of scores for the experimental condition had low levels of bias in the bootstrapping procedure. Experimental condition correlation coefficients for the Odd-One-Out subtest score were lower than those in the baseline condition, with coefficients with the experimental Mister X subtest score (r = .642, p = .007) and experimental Spatial Recall subtest (r = .652, p = .006) being moderate but statistically significant. However, the decline in strength of correlation was not also apparent for the experimental condition Mister X subtest score when correlated with the experimental condition Spatial Recall subtest score (r = .806, p = .000). When the coefficients over the repeated measures (baseline to experimental) are considered, only the Spatial Recall subtest retained an excessively strong correlation coefficient.

When correlation coefficients between the Visuo-spatial Working Memory baseline and experimental assessments were examined, it was apparent that coefficients were only extremely strong for the Spatial Recall test-retest relationship (r = .903, p = .000). This value implied a lack of external influence for this subtest. Statistically significant correlation coefficients were observed between the repeated measures for the Odd-One-Out subtest (r = .750, p = .001 and Mister X subtest (r = .750, p = .001) but the relationships were not of as excessive a strength. For the Visuo-spatial Working Memory subtest scores, the correlation coefficients were statistically significant but, excepting the Spatial Recall score, not of a sufficient magnitude to assume no external influences under the experimental condition.

Appendix D

Correlations between the Brief Biphasic Alcohol Effects Scale Items, Participant Age and Drinking Habits

Table D1

Energised Scale In The First Half of the Assessment: Pearson's r and Spearman's Rho Correlation Coefficients between the B-BAES Items at Each Measurement Point, Participant Age, Weekly Alcohol Consumption and Binge Drinking Episodes (n = 16)

	Pearson's r			*Spearman's rho*		
	Age	*Weekly Units*	*Binge Episodes*	*Age*	*Weekly Units*	*Binge Episodes*
Energised Pre-Alcohol	-0.361	0.308	0.287	-0.408	0.362	0.258
Excited Pre-Alcohol	-0.295	-0.092	-0.086	-0.336	-0.061	-0.114
Up Pre-Alcohol	-0.486	.530*	.528*	-0.478	.550*	0.471
Energised Point 1	-.535*	0.350	0.228	-.502*	0.319	0.174
Excited Point 1	-0.332	0.015	-0.204	-0.314	0.078	-0.234
Up Point 1	-.598*	.525*	0.497	-.588*	.597*	0.439
Energised Point 2	-.610*	0.297	0.435	-.654**	0.304	0.314
Excited Point 2	-0.260	-0.081	-0.119	-0.236	-0.059	-0.155
Up Point 2	-0.496	0.448	0.488	-0.473	.506*	0.430
Energised Point 3	-0.291	0.219	0.381	-0.245	0.163	0.271
Excited Point 3	-0.119	0.053	0.209	-0.186	0.061	0.069
Up Point 3	-0.385	0.236	0.346	-0.380	0.247	0.238
Energised Point 4	-.542*	0.331	0.335	-.569*	0.348	0.179
Excited Point 4	-0.328	0.190	0.278	-0.313	0.195	0.160
Up Point 4	-.601*	0.398	0.233	-.598*	0.428	0.134
Energised Point 5	-.709**	0.259	0.435	-.751**	0.320	0.400
Excited Point 5	-.537*	0.337	0.355	-.570*	0.338	0.247
Up Point 5	-.754**	.516*	0.486	-.781**	.580*	0.421
Energised Point 6	-.643**	0.329	0.374	-.743**	0.331	0.261
Excited Point 6	-0.462	0.167	0.342	-0.459	0.112	0.185
Up Point 6	-.618*	0.470	0.388	-.621*	0.459	0.294

* Significant at the 5% level

** Significant at the 1% level

Table D2

Energised Scale In The Second Half of the Assessment: Pearson's r and Spearman's Rho Correlation Coefficients between the B-BAES Items at Each Measurement Point, Participant Age, Weekly Alcohol Consumption and Binge Drinking Episodes (n = 16)

	Pearson's r			*Spearman's rho*		
	Age	*Weekly Units*	*Binge Episodes*	*Age*	*Weekly Units*	*Binge Episodes*
Energised Point 7	-.574*	0.302	0.493	-.634**	0.244	0.359
Excited Point 7	-0.292	0.235	0.439	-0.255	0.145	0.334
Up Point 7	-.521*	0.293	0.429	-.516*	0.239	0.227
Energised Point 8	-.520*	0.233	0.461	-.566*	0.244	0.395
Excited Point 8	-0.394	0.172	0.396	-0.443	0.152	0.289
Up Point 8	-0.497	0.410	0.459	-.510*	0.459	0.411
Energised Point 9	-0.279	0.194	0.446	-0.247	0.084	0.390
Excited Point 9	-0.306	0.159	0.419	-0.329	0.117	0.323
Up Point 9	-0.321	0.255	0.472	-0.301	0.204	0.466
Energised Point 10	-0.151	-0.260	0.168	-0.227	-0.228	0.132
Excited Point 10	-0.262	-0.037	0.273	-0.265	-0.068	0.187
Up Point 10	-0.230	0.016	0.313	-0.343	0.071	0.314
Energised Point 11	-0.334	0.131	0.410	-0.299	-0.084	0.206
Excited Point 11	-0.283	0.034	0.344	-0.263	-0.062	0.199
Up Point 11	-0.326	0.175	0.345	-0.255	0.113	0.313
Energised Point 12	-0.407	0.231	0.455	-0.428	0.193	0.246
Excited Point 12	-0.246	0.152	0.380	-0.192	0.046	0.232
Up Point 12	-0.456	0.227	0.447	-.512*	0.215	0.290
Energised Post-test	-0.167	-0.030	0.221	-0.118	-0.106	0.137
Excited Post-test	-0.087	0.017	0.228	-0.040	-0.111	0.091
Up Post-test	-0.231	0.047	0.263	-0.207	0.050	0.215

* Significant at the 5% level

** Significant at the 1% level

Table D3

Sedated Scale In The First Half of the Assessment: Pearson's r and Spearman's Rho Correlation Coefficients between the B-BAES Items at Each Measurement Point, Participant Age, Weekly Alcohol Consumption and Binge Drinking Episodes (n = 16)

	Pearson's r			*Spearman's rho*		
	Age	*Weekly Units*	*Binge Episodes*	*Age*	*Weekly Units*	*Binge Episodes*
Sedated Pre-alcohol	0.239	-0.439	-.567*	0.115	-0.424	-.584*
Slow Pre-alcohol	0.034	-.575*	-0.069	0.091	-.630**	-0.094
Sluggish Pre-alcohol	0.014	-0.156	-0.098	-0.010	-0.177	-0.103
Sedated Point 1	-0.088	-0.263	-0.339	-0.216	-0.196	-0.380
Slow Point 1	-0.070	-0.254	0.090	-0.033	-0.279	0.118
Sluggish Point 1	-0.081	-0.284	-0.269	-0.180	-0.243	-0.253
Sedated Point 2	-0.314	-0.193	-0.456	-0.263	-0.184	-0.475
Slow Point 2	-0.163	0.019	0.191	-0.119	0.008	0.174
Sluggish Point 2	-0.190	-0.119	-0.081	-0.257	-0.034	-0.110
Sedated Point 3	-0.205	-0.151	-0.183	-0.199	-0.130	-0.237
Slow Point 3	-0.332	-0.112	-0.063	-0.322	-0.196	-0.161
Sluggish Point 3	-0.137	-0.038	0.113	-0.190	-0.005	0.084
Sedated Point 4	-0.124	-0.192	-0.165	-0.131	-0.189	-0.221
Slow Point 4	-0.219	0.187	0.323	-0.241	0.126	0.287
Sluggish Point 4	-0.098	0.088	0.129	-0.216	0.152	0.142
Sedated Point 5	-0.021	-0.188	-0.199	-0.062	-0.150	-0.250
Slow Point 5	-0.065	0.052	0.177	-0.168	0.002	0.142
Sluggish Point 5	0.096	0.189	0.181	0.006	0.206	0.174
Sedated Point 6	-0.144	-0.052	-0.162	-0.148	-0.052	-0.231
Slow Point 6	-0.134	0.060	0.189	-0.215	0.093	0.239
Sluggish Point 6	-0.135	0.009	0.014	-0.155	0.011	0.000

* Significant at the 5% level

** Significant at the 1% level

Table D4

Sedated Scale In The Second Half of the Assessment: Pearson's r and Spearman's Rho Correlation Coefficients between the B-BAES Items at Each Measurement Point, Participant Age, Weekly Alcohol Consumption and Binge Drinking Episodes (n = 16)

	Pearson's r			*Spearman's rho*		
	Age	*Weekly Units*	*Binge Episodes*	*Age*	*Weekly Units*	*Binge Episodes*
Sedated Point 7	-0.171	-0.055	-0.027	-0.180	-0.049	-0.088
Slow Point 7	-0.449	0.021	0.092	-0.420	0.030	0.013
Sluggish Point 7	-0.015	0.068	0.199	-0.053	0.062	0.180
Sedated Point 8	-0.033	-0.017	-0.177	-0.002	-0.006	-0.151
Slow Point 8	-0.236	-0.103	0.123	-0.212	-0.089	0.209
Sluggish Point 8	-0.169	0.078	0.057	-0.164	0.047	0.064
Sedated Point 9	-0.022	-0.007	-0.097	-0.036	0.005	-0.128
Slow Point 9	-0.270	0.018	0.232	-0.358	0.006	0.107
Sluggish Point 9	0.028	-0.015	0.067	0.012	-0.016	0.057
Sedated Point 10	-0.122	0.043	-0.063	-0.096	0.036	-0.131
Slow Point 10	-0.257	0.029	0.125	-0.275	-0.006	0.030
Sluggish Point 10	-0.237	0.181	0.168	-0.171	0.173	0.142
Sedated Point 11	-0.056	0.025	-0.111	-0.075	0.059	-0.137
Slow Point 11	-0.276	0.087	0.128	-0.301	0.106	0.105
Sluggish Point 11	-0.056	0.113	-0.011	-0.049	0.105	-0.005
Sedated Point 12	-0.112	0.056	-0.124	-0.129	0.072	-0.122
Slow Point 12	-0.355	-0.022	0.011	-0.426	0.094	0.082
Sluggish Point 12	-0.200	0.072	-0.035	-0.154	0.056	-0.053
Sedated Post-test	-0.156	-0.042	-0.021	-0.188	0.067	0.020
Slow Post-test	-0.309	0.013	0.129	-0.360	0.145	0.255
Sluggish Post-test	-0.236	0.066	0.097	-0.241	0.112	0.109

* Significant at the 5% level

** Significant at the 1% level

Appendix E

Correlations between the B-BAES Items and BAC Readings

Table E1

Pearson's r Correlation Coefficients Between the First Half Assessment Energised B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Energised Pre-Alcohol	.430	.547*	.397	.538*	.421	.376	.258	.358	.387	.261	.377	.297	.202	.174
Excited Pre-Alcohol	.405	.587*	.488	.539*	.357	.271	.198	.257	.237	.258	.370	.389	.239	.309
Up Pre-Alcohol	.278	.304	.114	.318	.283	.354	.247	.279	.361	.187	.219	.085	.070	.067
Energised 1	.405	.492	.351	.493	.402	.423	.311	.314	.343	.279	.329	.244	.134	.226
Excited 1	.391	.688**	.492	.490	.379	.261	.232	.231	.176	.218	.276	.315	.133	.276
Up 1	.330	.230	.143	.350	.339	.459	.329	.347	.431	.295	.290	.129	.085	.154
Energised 2	.419	.229	.186	.392	.350	.455	.435	.429	.489	.454	.449	.398	.395	.403
Excited 2	.404	.573*	.424	.467	.339	.256	.232	.300	.263	.318	.382	.430	.277	.282
Up 2	.399	.159	.148	.340	.430	.532*	.448	.490	.557*	.425	.367	.214	.160	.138
Energised 3	.468	.451	.328	.503*	.470	.456	.413	.451	.478	.380	.421	.353	.211	.212
Excited 3	.300	.453	.274	.388	.262	.196	.173	.217	.218	.163	.289	.294	.209	.159
Up 3	.520*	.320	.333	.490	.544*	.586*	.497	.579*	.616*	.508*	.512*	.338	.215	.303
Energised 4	.430	.344	.270	.449	.427	.503*	.432	.424	.458	.395	.358	.279	.166	.264
Excited 4	.301	.361	.183	.361	.303	.336	.294	.249	.283	.216	.199	.192	.073	.042
Up 4	.465	.425	.359	.478	.489	.525*	.425	.461	.469	.400	.374	.250	.137	.298
Energised 5	.580*	.450	.377	.559*	.556*	.589*	.591*	.566*	.602*	.547*	.513*	.475	.411	.410
Excited 5	.320	.287	.085	.258	.293	.365	.389	.315	.366	.320	.272	.274	.218	.166
Up 5	.500*	.316	.284	.455	.500*	.581*	.529*	.537*	.583*	.502*	.450	.327	.292	.383
Energised 6	.316	.172	.053	.243	.306	.397	.389	.346	.403	.366	.309	.267	.226	.273
Excited 6	.199	.107	-.029	.178	.172	.267	.244	.199	.270	.239	.219	.209	.160	.138
Up 6	.227	.118	.004	.145	.232	.321	.311	.284	.324	.268	.201	.121	.121	.266

* Significant at the 5% level

** Significant at the 1% level

Table E2

Pearson's r Correlation Coefficients Between the Second Half Assessment Energised B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Energised 7	.461	.316	.254	.446	.479	.482	.475	.468	.504*	.418	.430	.374	.335	.355
Excited 7	.251	.311	.095	.284	.241	.244	.235	.226	.277	.157	.206	.207	.142	.084
Up 7	.392	.208	.219	.363	.406	.408	.391	.441	.462	.400	.393	.306	.288	.417
Energised 8	.287	.145	.034	.240	.249	.346	.328	.330	.399	.327	.315	.249	.241	.266
Excited 8	.179	.025	-.089	.101	.116	.218	.249	.223	.292	.261	.239	.261	.268	.153
Up 8	.283	.131	.064	.212	.260	.329	.324	.351	.387	.321	.310	.231	.235	.317
Energised 9	.128	.148	-.047	.138	.107	.119	.108	.134	.193	.099	.165	.140	.124	.142
Excited 9	.216	.166	.009	.212	.185	.237	.233	.212	.280	.197	.239	.232	.197	.132
Up 9	.109	.154	-.027	.142	.132	.102	.062	.128	.181	.053	.112	.044	.041	.148
Energised 10	.275	.190	.107	.219	.229	.212	.226	.309	.348	.336	.362	.343	.247	.203
Excited 10	.293	.231	.119	.298	.241	.256	.248	.275	.329	.303	.350	.350	.282	.217
Up 10	.219	-.010	-.021	.104	.191	.221	.225	.326	.380	.341	.355	.266	.254	.266
Energised 11	.104	-.049	-.133	.044	.072	.123	.156	.161	.213	.210	.193	.185	.186	.240
Excited 11	.144	-.038	-.103	.078	.065	.144	.213	.171	.235	.249	.253	.298	.335	.265
Up 11	.038	-.114	-.182	-.053	.029	.076	.094	.135	.176	.165	.122	.076	.086	.212
Energised 12	.175	.034	-.071	.157	.168	.273	.217	.227	.306	.228	.198	.120	.100	.096
Excited 12	.044	.081	-.139	.063	.012	.074	.057	.042	.109	.045	.059	.061	.046	-.011
Up 12	.287	-.040	.027	.246	.318	.437	.358	.382	.460	.383	.305	.180	.139	.176
Energised Post-test-test	.234	.259	.092	.191	.176	.130	.191	.249	.256	.238	.284	.300	.280	.264
Excited Post-test-test	.163	.199	.023	.144	.112	.104	.133	.167	.184	.169	.211	.226	.160	.122
Up Post-test-test	.298	.283	.134	.220	.249	.204	.278	.342	.350	.297	.332	.317	.332	.318

* Significant at the 5% level

** Significant at the 1% level

Table E3

Pearson's r Correlation Coefficients Between the First Half Assessment Sedated B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Sedated Pre-Alcohol	.237	.314	.338	.258	.300	.192	.155	.190	.114	.210	.170	.135	-.053	-.021
Slow Thoughts Pre-Alcohol	-.045	-.113	.070	.110	.012	-.143	-.185	-.111	-.114	-.029	.009	.093	.029	.106
Sluggish Pre-Alcohol	.529*	.467	.603*	.612*	.624**	.457	.379	.481	.445	.367	.454	.400	.197	.219
Sedated 1	.296	.209	.218	.211	.359	.341	.304	.323	.301	.329	.247	.202	.058	-.045
Slow Thoughts 1	.149	.177	.253	.277	.215	.018	.026	.088	.061	.048	.074	.178	.159	.054
Sluggish 1	.449	.230	.473	.484	.561*	.473	.362	.437	.411	.427	.424	.340	.098	.243
Sedated 2	.486	.587*	.541*	.509*	.555*	.437	.400	.367	.300	.351	.348	.364	.209	.166
Slow Thoughts 2	.124	.118	.149	.268	.265	.209	.081	.082	.103	-.004	-.018	-.049	-.173	-.194
Sluggish 2	.157	.044	.102	.214	.276	.256	.124	.143	.178	.138	.112	.070	-.101	-.049
Sedated 3	.141	.180	.131	.213	.229	.213	.121	.063	.070	.039	.043	.031	-.011	-.128
Slow Thoughts 3	.025	-.167	.009	.066	.122	.135	.072	.014	.009	.080	-.024	-.004	-.032	-.004
Sluggish 3	.246	.158	.184	.295	.323	.209	.141	.236	.269	.193	.253	.261	.146	.080
Sedated 4	.285	.249	.265	.325	.385	.324	.294	.220	.212	.182	.180	.176	.093	.030
Slow Thoughts 4	-.024	-.230	-.160	-.028	.088	.151	.142	.027	.069	-.004	-.112	-.115	-.111	-.120
Sluggish 4	.134	-.033	.033	.147	.227	.207	.158	.158	.188	.122	.116	.120	-.006	.037
Sedated 5	.087	.047	.029	.084	.192	.191	.158	.074	.083	.048	-.018	-.030	-.078	-.196
Slow Thoughts 5	.018	-.217	-.043	.040	.134	.173	.167	.052	.070	.029	-.081	-.081	-.113	-.065
Sluggish 5	.034	-.087	-.059	.041	.117	.111	.135	.071	.106	-.002	-.054	-.004	-.054	-.085
Sedated 6	.121	.114	.044	.121	.238	.239	.194	.092	.100	.072	-.007	-.027	-.094	-.193
Slow Thoughts 6	-.014	-.201	-.051	.020	.078	.096	.095	.014	.035	-.018	-.121	-.076	-.032	-.118
Sluggish 6	.145	-.217	.023	.103	.230	.260	.247	.209	.238	.253	.132	.162	.061	.097

* Significant at the 5% level

** Significant at the 1% level

Table E4

Pearson's r Correlation Coefficients Between the Second Half Assessment Sedated B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Sedated 7	.185	.152	.104	.214	.236	.225	.201	.132	.155	.101	.120	.143	.182	-.068
Slow Thoughts 7	.229	-.034	.192	.273	.271	.283	.287	.181	.178	.236	.178	.252	.325	.201
Sluggish 7	.088	-.101	.020	.113	.175	.116	.136	.119	.150	.065	.032	.106	.093	.000
Sedated 8	.222	.328	.254	.259	.335	.243	.248	.155	.133	.054	.016	.045	-.006	-.136
Slow Thoughts 8	.017	-.124	.045	.128	.060	.024	.022	-.054	-.038	-.034	-.009	.083	.216	.097
Sluggish 8	.141	.077	.136	.208	.251	.134	.130	.109	.114	.074	.037	.122	.054	.065
Sedated 9	.185	.325	.231	.273	.334	.235	.180	.115	.095	.012	-.021	-.066	-.150	-.199
Slow Thoughts 9	.345	.076	.284	.440	.477	.499*	.382	.324	.356	.299	.248	.138	.030	.051
Sluggish 9	.286	.301	.325	.340	.374	.153	.208	.249	.219	.157	.186	.279	.215	.120
Sedated 10	.176	.414	.241	.304	.317	.195	.120	.074	.058	-.045	-.041	-.068	-.154	-.174
Slow Thoughts 10	.236	.141	.265	.380	.387	.359	.228	.180	.189	.136	.080	.000	-.118	-.047
Sluggish 10	.150	.226	.160	.257	.255	.108	.093	.084	.091	.012	.015	.094	.051	.020
Sedated 11	.329	.489	.381	.402	.469	.307	.273	.250	.208	.143	.135	.101	-.032	-.060
Slow Thoughts 11	.329	.285	.367	.455	.469	.408	.300	.270	.267	.187	.136	.076	-.030	-.060
Sluggish 11	.410	.444	.437	.439	.535*	.343	.384	.361	.318	.257	.233	.279	.116	.122
Sedated 12	.386	.559*	.491	.507*	.527*	.371	.300	.277	.228	.161	.159	.118	-.039	-.047
Slow Thoughts 12	.297	.208	.326	.430	.433	.421	.246	.234	.244	.223	.161	.051	-.105	-.034
Sluggish 12	.464	.514*	.505*	.543*	.585*	.394	.347	.395	.354	.313	.321	.320	.128	.149
Sedated Post-test-test	.277	.397	.375	.466	.401	.287	.136	.161	.161	.077	.119	.052	-.053	-.100
Slow Thoughts Post-test-test	.171	.089	.184	.305	.308	.291	.146	.130	.152	.111	.035	-.046	-.142	-.099
Sluggish Post-test-test	.348	.320	.387	.475	.467	.323	.253	.279	.274	.213	.215	.220	.109	.101

* Significant at the 5% level

** Significant at the 1% level

Table E5

Spearman's rho Correlation Coefficients Between the First Half Assessment Energised B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Energised Pre-Alcohol	.469	.706**	.461	.531*	.405	.382	.271	.324	.354	.237	.374	.330	.189	.095
Excited Pre-Alcohol	.448	.617*	.490	.530*	.323	.284	.223	.205	.190	.208	.337	.329	.155	.255
Sedated Pre-Alcohol	.339	.212	.287	.290	.359	.257	.253	.273	.234	.343	.292	.303	.131	.117
Energised 1	.454	.592*	.412	.492	.371	.400	.302	.277	.298	.208	.290	.226	.068	.198
Excited 1	.448	.691**	.443	.465	.357	.283	.257	.227	.172	.172	.235	.237	.071	.269
Up 1	.395	.450	.267	.356	.350	.447	.322	.349	.402	.263	.261	.159	.047	.080
Energised 2	.470	.362	.281	.390	.322	.458	.444	.419	.470	.442	.446	.397	.349	.357
Excited 2	.413	.611*	.372	.449	.277	.233	.232	.238	.208	.266	.362	.387	.230	.232
Up 2	.354	.305	.144	.256	.380	.446	.355	.429	.488	.375	.313	.227	.125	-.002
Energised 3	.442	.685**	.367	.469	.395	.359	.387	.420	.442	.316	.417	.386	.216	.139
Excited 3	.309	.569*	.274	.362	.232	.224	.256	.235	.244	.174	.299	.303	.150	.121
Up 3	.448	.486	.299	.396	.478	.491	.473	.540*	.562*	.473	.479	.395	.245	.234
Energised 4	.475	.499*	.294	.398	.382	.495	.410	.413	.436	.357	.306	.230	.076	.173
Excited 4	.357	.527*	.216	.326	.251	.291	.251	.237	.263	.160	.152	.134	-.040	-.080
Up 4	.516*	.549*	.373	.450	.478	.540*	.427	.465	.463	.391	.358	.279	.162	.273
Energised 5	.600*	.511*	.376	.478	.527*	.599*	.601*	.595*	.634**	.556*	.516*	.474	.362	.317
Excited 5	.397	.431	.134	.246	.313	.368	.399	.362	.397	.334	.269	.257	.138	.092
Up 5	.557*	.460	.324	.419	.513*	.594*	.515*	.543*	.579*	.483	.406	.328	.261	.273
Energised 6	.412	.293	.116	.233	.358	.477	.462	.423	.476	.412	.314	.254	.174	.217
Excited 6	.225	.246	.005	.132	.126	.218	.229	.174	.221	.191	.153	.133	.019	.018
Up 6	.272	.227	.035	.140	.267	.373	.313	.310	.335	.246	.148	.067	.041	.178

* Significant at the 5% level

** Significant at the 1% level

Table E6

Spearman's rho Correlation Coefficients Between the Second Half Assessment Energised B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Energised 7	.494	.514*	.340	.436	.518*	.506*	.510*	.512*	.549*	.419	.470	.417	.343	.338
Excited 7	.223	.490	.141	.253	.174	.167	.174	.175	.216	.075	.170	.165	.060	-.060
Up 7	.378	.363	.214	.302	.413	.392	.364	.410	.412	.349	.337	.278	.261	.325
Energised 8	.351	.304	.150	.270	.282	.410	.411	.412	.470	.395	.382	.309	.237	.236
Excited 8	.202	.172	-.024	.099	.119	.224	.269	.252	.309	.297	.281	.286	.229	.066
Up 8	.265	.246	.068	.169	.275	.393	.391	.420	.452	.351	.313	.253	.232	.225
Energised 9	.152	.350	.078	.199	.145	.147	.174	.173	.219	.087	.198	.152	.073	.067
Excited 9	.204	.345	.080	.202	.155	.194	.226	.197	.250	.151	.224	.207	.104	.033
Up 9	.133	.330	.069	.179	.156	.098	.065	.107	.145	.001	.103	.033	.043	.077
Energised 10	.226	.300	.098	.195	.175	.144	.219	.247	.276	.312	.359	.341	.204	.110
Excited 10	.261	.367	.142	.263	.171	.166	.215	.200	.241	.227	.309	.300	.174	.096
Up 10	.143	.108	-.030	.074	.150	.171	.232	.274	.320	.334	.362	.303	.273	.227
Energised 11	-.008	-.084	-.231	-.093	-.056	.022	.103	.074	.115	.164	.132	.087	.075	.160
Excited 11	.083	.051	-.101	.027	-.018	.058	.159	.103	.147	.173	.190	.195	.170	.140
Up 11	-.073	-.109	-.302	-.172	-.069	-.024	.024	.056	.087	.116	.053	-.010	.018	.074
Energised 12	.237	.244	.008	.136	.179	.286	.257	.287	.343	.301	.256	.187	.084	.033
Excited 12	.114	.299	-.013	.114	.013	.069	.083	.072	.119	.056	.105	.089	-.013	-.090
Up 12	.317	.102	.065	.189	.316	.421	.348	.389	.448	.420	.309	.218	.121	.092
Energised Post-test-test	.152	.280	.043	.146	.080	.048	.154	.185	.192	.213	.299	.311	.315	.228
Excited Post-test-test	.097	.291	.008	.122	.031	.038	.120	.125	.140	.142	.225	.226	.111	.054
Up Post-test-test	.242	.367	.131	.217	.206	.138	.232	.286	.286	.263	.348	.346	.399	.322

* Significant at the 5% level

** Significant at the 1% level

Table E7

Spearman's rho Correlation Coefficients Between the First Half Assessment Sedated B-BAES Items and BAC Points (n = 16)

	Average BAC	*BAC 1*	*BAC 2*	*BAC 3*	*BAC 4*	*BAC 5*	*BAC 6*	*BAC 7*	*BAC 8*	*BAC 9*	*BAC 10*	*BAC 11*	*BAC 12*	*BAC 13 Post-test*
Sedated Pre-Alcohol	.339	.212	.287	.290	.359	.257	.253	.273	.234	.343	.292	.303	.131	.117
Slow Thoughts Pre-Alcohol	.008	-.198	.090	.136	.032	-.096	-.120	-.132	-.150	-.008	.046	.071	.008	.073
Sluggish Pre-Alcohol	.458	.479	.570*	.573*	.598*	.437	.388	.448	.423	.358	.482	.468	.263	.218
Sedated 1	.325	.205	.138	.171	.380	.349	.340	.373	.371	.445	.345	.351	.175	.034
Slow Thoughts 1	.267	.137	.296	.341	.313	.109	.080	.121	.092	.111	.146	.213	.216	.062
Sluggish 1	.417	.183	.397	.415	.556*	.474	.403	.427	.404	.436	.409	.361	.147	.258
Sedated 2	.518*	.495	.476	.491	.569*	.439	.369	.347	.307	.322	.332	.358	.172	.184
Slow Thoughts 2	.219	.230	.197	.281	.337	.233	.081	.121	.133	.015	.002	-.016	-.172	-.273
Sluggish 2	.199	.189	.075	.155	.296	.239	.123	.135	.151	.116	.072	.045	-.139	-.160
Sedated 3	.245	.244	.186	.245	.306	.243	.117	.098	.111	.054	.062	.069	-.042	-.122
Slow Thoughts 3	.258	-.121	.113	.188	.331	.290	.204	.174	.159	.247	.123	.130	.063	.120
Sluggish 3	.259	.334	.225	.293	.354	.208	.156	.204	.222	.182	.278	.282	.144	-.012
Sedated 4	.345	.295	.287	.342	.439	.330	.278	.250	.245	.174	.179	.185	.053	.040
Slow Thoughts 4	.111	-.089	-.050	.052	.222	.218	.128	.122	.154	.040	-.083	-.100	-.128	-.191
Sluggish 4	.164	.191	.064	.164	.279	.244	.167	.177	.194	.097	.090	.065	-.088	-.101
Sedated 5	.209	.120	.067	.119	.302	.233	.172	.166	.177	.124	.026	.033	-.085	-.192
Slow Thoughts 5	.165	-.087	.043	.128	.282	.262	.180	.159	.167	.085	-.045	-.068	-.138	-.085
Sluggish 5	.123	.071	-.001	.074	.199	.173	.151	.162	.177	.046	-.028	-.012	-.050	-.171
Sedated 6	.225	.157	.043	.120	.314	.248	.175	.158	.169	.116	.007	.008	-.124	-.197
Slow Thoughts 6	.166	-.099	.037	.104	.247	.200	.119	.128	.140	.067	-.054	-.030	.026	-.104
Sluggish 6	.171	-.139	.008	.084	.260	.258	.201	.206	.217	.242	.108	.104	-.002	-.041

* Significant at the 5% level

** Significant at the 1% level

Appendix F

Correlations between the baseline and experimental AWMA scores

Each of the subtests of the AWMA was analysed to assess the strength of relationship before and after alcohol consumption. Since the same assessment was used, a strong correlation coefficient was expected. However, excessively strong correlations were undesirable as these may indicate excessive practice effects, a lack of variance, or a negligible alteration due to alcohol consumption. Table F1 shows the repeated measures correlations for each of the AWMA subtests over the baseline to experimental condition. Appendix C explained the baseline to experimental interrelationships of the various subtests.

Table F1

Pearson's r Correlation Coefficients Between the Baseline and Experimental Measurements of the AWMA subtests (n = 16)

	r	*p*
Digit Recall	.843**	.000
Word Recall	.856**	.000
Nonword Recall	.393	.132
Dot Matrix	.747**	.001
Mazes Memory	.439	.089
Block Recall	.770**	.000
Listening Recall	.701**	.002
Counting Recall	.547*	.028
Backwards Digit	.741**	.001
Odd-one-out	.750**	.001
Mister X	.750**	.001
Spatial Recall	.903**	.000

* Significant at the 5% level

** Significant at the 1% level

The Digit Recall baseline assessment was significantly correlated with its experimental counterpart (r = .843, p = .000). The repeated measures for Word Recall were significantly correlated (r = .856, p = .000). However, the Nonword Recall baseline subtest was not significantly correlated with its experimental counterpart (r = .393, p = .132). The subtests measuring short-term memory in the verbal sphere were strongly correlated, excepting the Nonword Recall subtest. The deviation raises concerns over the functioning of this subtest or points to a change in performance under the experimental condition.

The baseline Dot Matrix score was significantly correlated with its matched experimental score (r = .747, p = .001) and the baseline Mazes Memory was only moderately

associated with the experimental measurement (r = .439, p = .089). The lack of excessive strength of correlation between the two Mazes Memory assessments implies change over the two conditions. The Block Recall baseline measurement and experimental measurement were strongly correlated (r = .770, p = .000). For the Visuo-spatial Short-term Memory subtests, it is apparent that associations are present between the components although the Mazes Memory subtest appears to operate somewhat differently.

The baseline to experimental correlation coefficient for the Listening Recall subtest was not excessively large (r = .701, p = .002), reducing concerns of collinearity and implying potential for external influence. The Counting Recall subtest's own repeated measures were weaker than those within conditions, although still statistically significant (r = .547, p = .028). The Backwards Digit baseline score showed the strongest of the baseline to experimental administration correlations between the repeated measures (r = .741, p = .001). The Verbal Working Memory subtests showed a reduction in strength in the repeated measures correlations in comparison to the Verbal Short-term Memory subtests, suggesting greater influences under the experimental condition.

When correlation coefficients between the Visuo-spatial Working Memory baseline and experimental assessments are examined, it is apparent that the coefficient was extremely strong for the Spatial Recall (r = .903, p = .000) test-retest association. These values imply a lack of external influence for these subtests or some collinearity concern. Statistically significant correlation coefficients were observed between the repeated measures for the Odd-One-Out subtest (r = .750, p = .001) and Mister X subtest (r = .750, p = .001) although these were insufficient to assume collinearity of measurement. Excepting the Spatial Recall subtest, the correlation coefficients between the repeated measures on the Visuo-spatial Working Memory subtests suggest some external influence under the experimental condition, reducing concerns around collinearity. Understanding of the correlational relationships provides a foundation for consideration of the repeated measures differences over the subtests.

Appendix G

Repeated Measures *t*-test Comparisons of the AWMA Subtest Scores

To test the hypothesis of difference in performance under the experimental condition, test-retest comparisons were conducted. Firstly, a matched paired t-test was calculated to allow for a Bias Corrected accelerated (BCa) bootstrapping ($B = 1000$) component used to assess the potential for error due to the small sample size. Following these analyses, analysis of (co)variance models were calculated to include the important effect sizes present for formal assessment of the strength of the differences and to allow for the construction of models accounting for the identified covariates. Paired *t*-tests, with Bias Corrected accelerated (BCa) bootstrapped ($B = 1000$) parameters, were investigated as a preliminary indication of the statistical magnitude and importance of the differences observed. Since the t-tests do not provide specific effect size values, these calculations were used as an initial indication of the statistics of difference, as well as an assessment of the integrity of the statistics given the small sample size. Later, repeated measures analyses of covariance elaborate upon the research questions. The paired *t*-test results reported in Table G1 are reported along with a single bootstrapped (BCa, $B = 1000$) approximate result and values of bootstrapping bias.

Table G1 shows high congruence between the paired t-test and bootstrapped ($B = 1000$) paired t-test results. Levels of bias are low in all cases, generally between -0.100 and +0.100 with a few exceptions falling slightly outside of this range. In all cases, standard errors of the mean are highly similar, as are the upper and lower bounds of the 95% confidence interval of the difference between the baseline and experimental measure values. Based on the statistics calculated, two subtest scores were approaching significance ($p < .08$) whilst three values were significant at the $\alpha = .05$ threshold.

Table G1

Matched Pairs Repeated Measures t-tests for the AWMA Subtests with Bias Corrected Accelerated (B = 1000) Bootstrapping (n = 16)

	Description and Dispersion of the Difference					*BCa Bootstrapped Statistics (B = 1000)*				*Statistics*		
	*M**	*SD*	SE_{Mean}	*95% CI Lower*	*95% CI Upper*	*Bias*	SE_{Mean}	*95% CI Lower*	*95% CI Upper*	*t*	*p*	*p of BCa*
Digit Recall	-0.063	8.985	2.246	-4.850	4.725	-0.005	2.163	-4.188	4.125	-0.028	.978	.981
Word Recall	2.363	8.296	2.074	-2.058	6.783	0.034	2.021	-1.064	5.870	1.139	.273	.276
Nonword Recall	1.119	12.933	3.233	-5.773	8.010	0.025	3.106	-5.298	8.793	0.346	.734	.722
Dot Matrix	-3.000	11.518	2.880	-9.138	3.138	0.032	2.863	-8.125	2.006	-1.042	.314	.336
Mazes Memory	6.500	16.387	4.097	-2.232	15.232	-0.006	4.006	-0.750	13.250	1.587	.133	.142
Block Recall	-0.125	9.077	2.269	-4.962	4.712	0.066	2.269	-4.000	4.501	-0.055	.957	.948
Listening Recall	-5.125	10.751	2.688	-10.854	0.604	-0.090	2.582	-10.604	0.313	-1.907	.076	.090
Counting Recall	-6.625	11.401	2.850	-12.700	-0.550	0.017	2.765	-12.247	-1.313	-2.324	.035	.036
Backwards Digit	-6.813	13.712	3.428	-14.119	0.494	0.116	3.419	-14.351	-0.188	-1.987	.065	.087
Odd-One-Out	-0.938	9.909	2.477	-6.218	4.343	0.022	2.381	-6.040	4.576	-0.378	.710	.711
Mister X	-3.563	11.966	2.992	-9.939	2.814	0.075	2.754	-9.000	2.027	-1.191	.252	.224
Spatial Recall	0.938	7.380	1.845	-2.995	4.870	0.018	1.780	-2.563	4.813	0.508	.619	.598

* Negative values reflect improvements in performance, positive values reflect deteriorations in performance

None of the three subtests assessing baseline-experimental differences in short-term memory were statistically significant. The Digit Recall subtest performance improved during the experimental assessment ($M_{Difference}$ = -0.063, $SD_{Difference}$ = 8.895) but the difference was not statistically significant (t = -0.028, p = .978), reflecting the lack of variation between the two conditions. On the other hand, the Word Recall score deteriorated under the experimental condition ($M_{Difference}$ = 2.363, $SD_{Difference}$ = 8.296) but statistical significance for this difference was not achieved (t = 1.139, p = .273). The Nonword Recall subtest differences were not statistically significant (t = 0.346, p = .734), but also indicated a decline in performance under the experimental condition ($M_{Difference}$ = 1.119, $SD_{Difference}$ = 12.933). The Visuo-spatial Short-term Memory composite score values were also inconsistent in change in performance across the three contributing subtests.

The Mazes Memory subtest difference between the baseline and experimental conditions reflected a substantial deterioration in the mean score under the experimental condition ($M_{Difference}$ = 6.500, $SD_{Difference}$ = 16.387) although this change was not statistically significant (t = 1.587, p = .133). The Dot Matrix subtest mean scores were improved during the experimental condition ($M_{Difference}$ = -3.000, $SD_{Difference}$ = 11.518), but the improvements were not statistically significant (t = -1.042, p = .314). The Block Recall subtest improved fractionally ($M_{Difference}$ = -0.125, $SD_{Difference}$ = 9.077) without the difference being statistically significant (t = -0.055, p = .975). Although no statistically significant differences were found under these statistics for the short-term memory components, of the Verbal Working Memory scores, two were approaching significance ($p < .08$), whilst another two were statistically significant ($p < .05$).

The baseline Listening Recall subtest performance improved under experimental conditions ($M_{Difference}$ = -5.125, $SD_{Difference}$ = 10.751) but the statistical differences were not statistically significant (t = -1.907, p = .076). The Counting Recall subtest differences ($M_{Difference}$ = -6.625, $SD_{Difference}$ = 11.401) were statistically significant (t = -2.324, p = .035), based on an improved performance during the experimental assessment. Likewise, the Backwards Digit subtest (t = -1.987, p = .065) was not statistically significant, despite improved performance under the experimental condition ($M_{Difference}$ = -6.813, $SD_{Difference}$ = 13.712). However, this value was approaching statistical significance. The Verbal Working Memory subtests consistently improved during the experimental condition.

Mean differences in the Odd-one-out subtest ($M_{Difference}$ = -0.938, $SD_{Difference}$ = 9.909) was negative which implied a slight improvement in performance under the experimental condition. However, no statistically significant differences were apparent for the Odd-one-out

subtest (t = -0.378, p = .710). A similar absolute magnitude of difference was observed for the Spatial Recall subtest ($M_{\text{Difference}}$ = 0.938, $SD_{\text{Difference}}$ = 7.380) which rather showed fractional deterioration in value under the experimental condition. The fractional drop in scores was not statistically significant for changes in the mean on the Spatial Recall subtest (t = 0.508, p = .619). On the other hand, the Mister X subtest score improvement under the experimental condition was considerably larger ($M_{\text{Difference}}$ = -3.563, $SD_{\text{Difference}}$ = 11.966), although not statistically significant (t = -1.191, p = .252).

Although the paired t-test is useful due to the ability to incorporate a bootstrapping function, some important statistical information is not included. Further consideration was required to assess the values of the effect size in the form of partial eta squared ($\eta^2_{Partial}$) and the observed power, particularly given the attenuation of the probability of achieving statistical significance under considerations of small sample size.

Appendix H

Repeated Measures Analysis of Covariance Models Controlling for BAC at Every Measurement Point

Table H1

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for Average BAC (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	65.117	1	65.117	1.860	.194	.117	.246	115.396	1	115.396	3.297	.091	.191	.394	490.073	14	35.005
Word Recall	91.153	1	91.153	2.718	.121	.163	.336	46.627	1	46.627	1.390	.258	.090	.196	469.532	14	33.538
Nonword Recall	42.524	1	42.524	0.533	.478	.037	.105	136.555	1	136.555	1.710	.212	.109	.230	1117.967	14	79.855
Dot Matrix	2.810	1	2.810	0.041	.843	.003	.054	29.645	1	29.645	0.430	.523	.030	.094	965.355	14	68.954
Mazes Memory	187.081	1	187.081	1.303	.273	.085	.186	3.155	1	3.155	0.022	.884	.002	.052	2010.845	14	143.632
Block Recall	20.344	1	20.344	0.487	.497	.034	.100	33.326	1	33.326	0.798	.387	.054	.133	584.549	14	41.754
Listening Recall	148.946	1	148.946	2.436	.141	.148	.307	11.016	1	11.016	0.180	.678	.013	.068	855.859	14	61.133
Counting Recall	328.185	1	328.185	4.998	.042	.263	.548	55.524	1	55.524	0.846	.373	.057	.138	919.351	14	65.668
Backwards Digit	317.884	1	317.884	3.256	.093	.189	.390	43.328	1	43.328	0.444	.516	.031	.095	1366.891	14	97.635
Odd-One-Out	29.546	1	29.546	0.645	.435	.044	.116	95.129	1	95.129	2.077	.172	.129	.269	641.340	14	45.810
Mister X	71.274	1	71.274	0.934	.350	.063	.147	5.070	1	5.070	0.066	.800	.005	.057	1068.899	14	76.350
Spatial Recall	2.455	1	2.455	0.084	.776	.006	.058	0.085	1	.085	0.003	.958	.000	.050	408.383	14	29.170

* Type III Sum of Squares

Table H2

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 1 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	10.444	1	10.444	0.247	.627	.017	.075	13.835	1	13.835	0.327	.576	.023	.083	591.634	14	42.260
Word Recall	65.656	1	65.656	1.885	.191	.119	.249	28.623	1	28.623	0.822	.380	.055	.135	487.536	14	34.824
Nonword Recall	199.763	1	199.763	3.101	.100	.181	.375	352.538	1	352.538	5.472	.035	.281	.586	901.985	14	64.427
Dot Matrix	14.411	1	14.411	0.203	.659	.014	.070	0.821	1	0.821	0.012	.916	.001	.051	994.179	14	71.013
Mazes Memory	134.533	1	134.533	0.937	.349	.063	.147	4.154	1	4.154	0.029	.867	.002	.053	2009.846	14	143.560
Block Recall	25.121	1	25.121	0.601	.451	.041	.112	32.696	1	32.696	0.782	.391	.053	.131	585.179	14	41.799
Listening Recall	87.000	1	87.000	1.410	.255	.092	.198	3.323	1	3.323	0.054	.820	.004	.055	863.552	14	61.682
Counting Recall	146.506	1	146.506	2.117	.168	.131	.273	5.817	1	5.817	0.084	.776	.006	.058	969.058	14	69.218
Backwards Digit	280.814	1	280.814	2.907	.110	.172	.355	57.637	1	57.637	0.597	.453	.041	.111	1352.582	14	96.613
Odd-One-Out	0.240	1	0.240	0.005	.947	.000	.050	5.154	1	5.154	0.099	.758	.007	.060	731.315	14	52.237
Mister X	169.537	1	169.537	2.391	.144	.146	.302	81.335	1	81.335	1.147	.302	.076	.170	992.634	14	70.902
Spatial Recall	0.075	1	0.075	0.003	.960	.000	.050	1.862	1	1.862	0.064	.804	.005	.056	406.607	14	29.043

* Type III Sum of Squares

Table H3

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 2 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	62.622	1	62.622	1.777	.204	.113	.237	112.096	1	112.096	3.181	.096	.185	.383	493.373	14	35.241
Word Recall	52.320	1	52.320	1.457	.247	.094	.203	13.558	1	13.558	.378	.549	.026	.088	502.601	14	35.900
Nonword Recall	137.968	1	137.968	2.150	.165	.133	.277	355.925	1	355.925	5.545	.034	.284	.592	898.597	14	64.186
Dot Matrix	.121	1	.121	.002	.967	.000	.050	68.456	1	68.456	1.034	.326	.069	.158	926.544	14	66.182
Mazes Memory	197.244	1	197.244	1.374	.261	.089	.194	4.729	1	4.729	.033	.859	.002	.053	2009.271	14	143.519
Block Recall	50.146	1	50.146	1.321	.270	.086	.188	86.393	1	86.393	2.276	.154	.140	.290	531.482	14	37.963
Listening Recall	191.613	1	191.613	3.205	.095	.186	.385	29.988	1	29.988	.502	.490	.035	.101	836.887	14	59.778
Counting Recall	296.583	1	296.583	4.432	.054	.240	.500	38.014	1	38.014	.568	.464	.039	.108	936.861	14	66.919
Backwards Digit	407.695	1	407.695	4.338	.056	.237	.492	94.331	1	94.331	1.004	.333	.067	.154	1315.887	14	93.992
Odd-One-Out	1.166	1	1.166	.023	.883	.002	.052	15.248	1	15.248	.296	.595	.021	.080	721.221	14	51.516
Mister X	219.308	1	219.308	3.211	.095	.187	.386	117.782	1	117.782	1.724	.210	.110	.232	956.187	14	68.299
Spatial Recall	.029	1	.029	.001	.975	.000	.050	4.874	1	4.874	.169	.687	.012	.067	403.595	14	28.828

* Type III Sum of Squares

Table H4

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 3 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	56.632	1	56.632	1.565	.232	.101	.215	98.706	1	98.706	2.727	.121	.163	.337	506.763	14	36.197
Word Recall	61.897	1	61.897	1.750	.207	.111	.234	20.972	1	20.972	0.593	.454	.041	.111	495.186	14	35.370
Nonword Recall	59.332	1	59.332	0.768	.396	.052	.129	173.160	1	173.160	2.242	.157	.138	.287	1081.362	14	77.240
Dot Matrix	1.053	1	1.053	0.015	.903	.001	.052	38.533	1	38.533	0.564	.465	.039	.108	956.467	14	68.319
Mazes Memory	180.398	1	180.398	1.256	.281	.082	.181	2.504	1	2.504	0.017	.897	.001	.052	2011.496	14	143.678
Block Recall	37.911	1	37.911	0.957	.345	.064	.149	63.075	1	63.075	1.592	.228	.102	.217	554.800	14	39.629
Listening Recall	220.681	1	220.681	3.775	.072	.212	.440	48.556	1	48.556	0.831	.377	.056	.136	818.319	14	58.451
Counting Recall	290.612	1	290.612	4.340	.056	.237	.492	37.408	1	37.408	0.559	.467	.038	.107	937.467	14	66.962
Backwards Digit	296.112	1	296.112	3.013	.105	.177	.366	34.311	1	34.311	0.349	.564	.024	.085	1375.907	14	98.279
Odd-One-Out	9.607	1	9.607	0.194	.666	.014	.070	42.602	1	42.602	0.860	.370	.058	.139	693.867	14	49.562
Mister X	149.245	1	149.245	2.049	.174	.128	.266	54.450	1	54.450	0.748	.402	.051	.127	1019.519	14	72.823
Spatial Recall	0.122	1	.122	0.004	.949	.000	.050	3.617	1	3.617	0.125	.729	.009	.063	404.852	14	28.918

* Type III Sum of Squares

Table H5

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 4 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	60.063	1	60.063	1.719	.211	.109	.231	116.281	1	116.281	3.328	.090	.192	.397	489.188	14	34.942
Word Recall	75.835	1	75.835	2.192	.161	.135	.281	31.734	1	31.734	0.917	.354	.061	.145	484.425	14	34.602
Nonword Recall	39.690	1	39.690	0.501	.491	.035	.101	145.778	1	145.778	1.841	.196	.116	.244	1108.744	14	79.196
Dot Matrix	3.361	1	3.361	0.049	.828	.003	.055	34.722	1	34.722	0.506	.488	.035	.102	960.278	14	68.591
Mazes Memory	225.000	1	225.000	1.570	.231	.101	.215	8.000	1	8.000	0.056	.817	.004	.056	2006.000	14	143.286
Block Recall	27.563	1	27.563	0.680	.424	.046	.120	50.000	1	50.000	1.233	.286	.081	.179	567.875	14	40.563
Listening Recall	166.840	1	166.840	2.739	.120	.164	.338	14.222	1	14.222	0.234	.636	.016	.074	852.653	14	60.904
Counting Recall	383.507	1	383.507	6.001	.028	.300	.625	80.222	1	80.222	1.255	.281	.082	.181	894.653	14	63.904
Backwards Digit	318.028	1	318.028	3.239	.094	.188	.389	35.420	1	35.420	0.361	.558	.025	.087	1374.799	14	98.200
Odd-One-Out	27.563	1	27.563	0.608	.449	.042	.112	101.531	1	101.531	2.239	.157	.138	.286	634.938	14	45.353
Mister X	73.674	1	73.674	0.964	.343	.064	.150	4.253	1	4.253	0.056	.817	.004	.056	1069.715	14	76.408
Spatial Recall	2.507	1	2.507	0.086	.774	.006	.059	0.170	1	0.170	0.006	.940	.000	.051	408.299	14	29.164

* Type III Sum of Squares

Table H6

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 5 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*Df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	51.828	1	51.828	1.447	.249	.094	.202	104.160	1	104.160	2.909	.110	.172	.356	501.309	14	35.808
Word Recall	83.355	1	83.355	2.444	.140	.149	.308	38.724	1	38.724	1.136	.305	.075	.169	477.435	14	34.102
Nonword Recall	15.709	1	15.709	0.187	.672	.013	.069	81.231	1	81.231	0.969	.342	.065	.151	1173.292	14	83.807
Dot Matrix	6.598	1	6.598	0.095	.762	.007	.060	26.240	1	26.240	0.379	.548	.026	.089	968.760	14	69.197
Mazes Memory	108.805	1	108.805	0.763	.397	.052	.129	16.623	1	16.623	0.117	.738	.008	.062	1997.377	14	142.670
Block Recall	3.760	1	3.760	0.086	.774	.006	.059	5.908	1	5.908	0.135	.719	.010	.064	611.967	14	43.712
Listening Recall	109.620	1	109.620	1.770	.205	.112	.237	0.001	1	0.001	0.000	.997	.000	.050	866.874	14	61.920
Counting Recall	387.546	1	387.546	6.059	.027	.302	.630	79.427	1	79.427	1.242	.284	.081	.180	895.448	14	63.961
Backwards Digit	263.100	1	263.100	2.633	.127	.158	.327	11.279	1	11.279	0.113	.742	.008	.061	1398.940	14	99.924
Odd-One-Out	41.778	1	41.778	0.991	.336	.066	.153	146.111	1	146.111	3.465	.084	.198	.411	590.358	14	42.168
Mister X	59.988	1	59.988	0.782	.391	.053	.131	0.480	1	0.480	0.006	.938	.000	.051	1073.489	14	76.678
Spatial Recall	0.995	1	0.995	0.034	.856	.002	.053	1.742	1	1.742	0.060	.810	.004	.056	406.727	14	29.052

* Type III Sum of Squares

Table H7

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 6 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*Df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	44.713	1	44.713	1.217	.289	.080	.177	91.002	1	91.002	2.476	.138	.150	.311	514.467	14	36.748
Word Recall	92.547	1	92.547	2.768	.118	.165	.341	48.091	1	48.091	1.438	.250	.093	.201	468.068	14	33.433
Nonword Recall	5.191	1	5.191	0.060	.810	.004	.056	44.307	1	44.307	0.513	.486	.035	.102	1210.215	14	86.444
Dot Matrix	15.890	1	15.890	0.226	.642	.016	.073	10.015	1	10.015	0.142	.712	.010	.064	984.985	14	70.356
Mazes Memory	142.281	1	142.281	0.991	.336	.066	.153	4.281	1	4.281	0.030	.865	.002	.053	2009.719	14	143.551
Block Recall	2.750	1	2.750	0.063	.806	.004	.056	4.156	1	4.156	0.095	.763	.007	.060	613.719	14	43.837
Listening Recall	124.882	1	124.882	2.019	.177	.126	.263	0.890	1	0.890	0.014	.906	.001	.051	865.985	14	61.856
Counting Recall	343.126	1	343.126	5.200	.039	.271	.565	51.134	1	51.134	0.775	.394	.052	.130	923.741	14	65.981
Backwards Digit	247.729	1	247.729	2.471	.138	.150	.311	6.456	1	6.456	0.064	.803	.005	.056	1403.763	14	100.269
Odd-One-Out	54.675	1	54.675	1.385	.259	.090	.195	183.769	1	183.769	4.655	.049	.250	.519	552.700	14	39.479
Mister X	31.263	1	31.263	0.410	.532	.028	.092	6.302	1	6.302	0.083	.778	.006	.058	1067.667	14	76.262
Spatial Recall	2.700	1	2.700	0.093	.765	.007	.059	0.169	1	0.169	0.006	.940	.000	.051	408.300	14	29.164

* Type III Sum of Squares

Table H8

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 7 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	50.275	1	50.275	1.431	.251	.093	.200	113.678	1	113.678	3.236	.094	.188	.388	491.791	14	35.128
Word Recall	79.232	1	79.232	2.303	.151	.141	.293	34.590	1	34.590	1.006	.333	.067	.155	481.569	14	34.398
Nonword Recall	15.757	1	15.757	0.190	.669	.013	.069	95.242	1	95.242	1.150	.302	.076	.170	1159.280	14	82.806
Dot Matrix	11.695	1	11.695	0.168	.688	.012	.067	21.290	1	21.290	0.306	.589	.021	.081	973.710	14	69.551
Mazes Memory	183.767	1	183.767	1.278	.277	.084	.184	0.333	1	0.333	0.002	.962	.000	.050	2013.667	14	143.833
Block Recall	9.357	1	9.357	0.218	.647	.015	.072	18.298	1	18.298	0.427	.524	.030	.094	599.577	14	42.827
Listening Recall	167.440	1	167.440	2.732	.121	.163	.338	8.976	1	8.976	0.146	.708	.010	.065	857.899	14	61.279
Counting Recall	408.478	1	408.478	6.425	.024	.315	.655	84.863	1	84.863	1.335	.267	.087	.190	890.012	14	63.572
Backwards Digit	360.517	1	360.517	3.697	.075	.209	.433	45.169	1	45.169	0.463	.507	.032	.097	1365.049	14	97.504
Odd-One-Out	19.024	1	19.024	0.415	.530	.029	.092	95.352	1	95.352	2.082	.171	.129	.270	641.117	14	45.794
Mister X	55.393	1	55.393	0.722	.410	.049	.125	0.088	1	0.088	0.001	.973	.000	.050	1073.881	14	76.706
Spatial Recall	10.551	1	10.551	0.365	.555	.025	.087	3.604	1	3.604	0.125	.729	.009	.063	404.864	14	28.919

* Type III Sum of Squares

Table H9

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 8 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	43.521	1	43.521	1.203	.291	.079	.176	99.000	1	99.000	2.737	.120	.164	.338	506.468	14	36.176
Word Recall	89.981	1	89.981	2.679	.124	.161	.332	45.996	1	45.996	1.370	.261	.089	.194	470.163	14	33.583
Nonword Recall	2.372	1	2.372	0.027	.871	.002	.053	36.913	1	36.913	0.424	.525	.029	.093	1217.609	14	86.972
Dot Matrix	14.055	1	14.055	0.201	.661	.014	.070	17.315	1	17.315	0.248	.626	.017	.075	977.685	14	69.835
Mazes Memory	178.716	1	178.716	1.243	.284	.082	.180	0.883	1	0.883	0.006	.939	.000	.051	2013.117	14	143.794
Block Recall	3.459	1	3.459	0.079	.783	.006	.058	6.001	1	6.001	0.137	.717	.010	.064	611.874	14	43.705
Listening Recall	159.084	1	159.084	2.587	.130	.156	.323	6.001	1	6.001	0.098	.759	.007	.060	860.874	14	61.491
Counting Recall	418.595	1	418.595	6.634	.022	.322	.669	91.470	1	91.470	1.450	.249	.094	.202	883.405	14	63.100
Backwards Digit	327.812	1	327.812	3.321	.090	.192	.397	28.291	1	28.291	0.287	.601	.020	.079	1381.928	14	98.709
Odd-One-Out	20.554	1	20.554	0.453	.512	.031	.096	101.689	1	101.689	2.243	.156	.138	.287	634.779	14	45.341
Mister X	36.190	1	36.190	0.475	.502	.033	.099	6.419	1	6.419	0.084	.776	.006	.058	1067.550	14	76.254
Spatial Recall	12.162	1	12.162	0.422	.526	.029	.093	5.131	1	5.131	0.178	.679	.013	.068	403.338	14	28.810

* Type III Sum of Squares

Table H10

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 9 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	72.541	1	72.541	2.384	.145	.146	.301	179.473	1	179.473	5.898	.029	.296	.618	425.996	14	30.428
Word Recall	106.285	1	106.285	3.308	.090	.191	.395	66.374	1	66.374	2.066	.173	.129	.268	449.784	14	32.127
Nonword Recall	6.529	1	6.529	0.077	.786	.005	.058	64.523	1	64.523	0.759	.398	.051	.128	1190.000	14	85.000
Dot Matrix	14.322	1	14.322	0.206	.657	.014	.071	20.563	1	20.563	0.295	.595	.021	.080	974.437	14	69.603
Mazes Memory	233.235	1	233.235	1.623	.223	.104	.221	2.198	1	2.198	0.015	.903	.001	.052	2011.802	14	143.700
Block Recall	12.303	1	12.303	0.291	.598	.020	.080	26.696	1	26.696	0.632	.440	.043	.115	591.179	14	42.227
Listening Recall	152.776	1	152.776	2.475	.138	.150	.311	2.818	1	2.818	0.046	.834	.003	.055	864.057	14	61.718
Counting Recall	439.375	1	439.375	7.053	.019	.335	.695	102.769	1	102.769	1.650	.220	.105	.224	872.106	14	62.293
Backwards Digit	349.527	1	349.527	3.556	.080	.203	.419	34.264	1	34.264	0.349	.564	.024	.085	1375.954	14	98.282
Odd-One-Out	29.567	1	29.567	0.699	.417	.048	.122	144.035	1	144.035	3.404	.086	.196	.405	592.433	14	42.317
Mister X	41.965	1	41.965	0.550	.471	.038	.106	4.897	1	4.897	0.064	.804	.005	.056	1069.072	14	76.362
Spatial Recall	10.820	1	10.820	0.374	.550	.026	.088	3.807	1	3.807	0.132	.722	.009	.063	404.662	14	28.904

* Type III Sum of Squares

Table H11

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 10 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	45.930	1	45.930	1.344	.266	.088	.191	127.149	1	127.149	3.722	.074	.210	.435	478.320	14	34.166
Word Recall	97.579	1	97.579	2.981	.106	.176	.363	57.851	1	57.851	1.767	.205	.112	.236	458.308	14	32.736
Nonword Recall	1.646	1	1.646	0.019	.892	.001	.052	42.638	1	42.638	0.493	.494	.034	.100	1211.884	14	86.563
Dot Matrix	9.163	1	9.163	0.135	.719	.010	.064	42.471	1	42.471	0.624	.443	.043	.114	952.529	14	68.038
Mazes Memory	305.882	1	305.882	2.147	.165	.133	.277	19.882	1	19.882	0.140	.714	.010	.064	1994.118	14	142.437
Block Recall	14.190	1	14.190	0.341	.569	.024	.085	35.007	1	35.007	0.841	.375	.057	.137	582.868	14	41.633
Listening Recall	184.633	1	184.633	3.017	.104	.177	.366	10.066	1	10.066	0.164	.691	.012	.067	856.809	14	61.201
Counting Recall	389.784	1	389.784	5.971	.028	.299	.623	60.890	1	60.890	0.933	.351	.062	.147	913.985	14	65.285
Backwards Digit	436.948	1	436.948	4.605	.050	.248	.515	81.840	1	81.840	0.863	.369	.058	.139	1328.379	14	94.884
Odd-One-Out	9.471	1	9.471	0.202	.660	.014	.070	78.767	1	78.767	1.677	.216	.107	.227	657.702	14	46.979
Mister X	61.150	1	61.150	0.797	.387	.054	.132	0.311	1	0.311	0.004	.950	.000	.050	1073.658	14	76.690
Spatial Recall	5.154	1	5.154	0.177	.681	.012	.068	0.046	1	0.046	0.002	.969	.000	.050	408.423	14	29.173

* Type III Sum of Squares

Table H12

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 11 (n = 16)

	Model			*Model Statistics*				*Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	43.682	1	43.682	1.296	.274	.085	.186	133.651	1	133.651	3.966	.066	.221	.458	471.818	14	33.701
Word Recall	103.856	1	103.856	3.253	.093	.189	.390	69.205	1	69.205	2.168	.163	.134	.279	446.954	14	31.925
Nonword Recall	0.060	1	0.060	0.001	.980	.000	.050	18.104	1	18.104	0.205	.658	.014	.071	1236.419	14	88.316
Dot Matrix	10.920	1	10.920	0.161	.694	.011	.066	44.545	1	44.545	0.656	.431	.045	.118	950.455	14	67.890
Mazes Memory	436.545	1	436.545	3.197	.095	.186	.384	102.145	1	102.145	0.748	.402	.051	.127	1911.855	14	136.561
Block Recall	13.136	1	13.136	0.316	.583	.022	.082	35.511	1	35.511	0.854	.371	.057	.138	582.364	14	41.597
Listening Recall	229.136	1	229.136	3.838	.070	.215	.446	31.111	1	31.111	0.521	.482	.036	.103	835.764	14	59.697
Counting Recall	320.727	1	320.727	4.693	.048	.251	.523	18.002	1	18.002	0.263	.616	.018	.077	956.873	14	68.348
Backwards Digit	384.727	1	384.727	3.938	.067	.220	.455	42.346	1	42.346	0.433	.521	.030	.094	1367.873	14	97.705
Odd-One-Out	13.920	1	13.920	0.312	.585	.022	.082	112.514	1	112.514	2.525	.134	.153	.316	623.955	14	44.568
Mister X	40.909	1	40.909	0.539	.475	.037	.105	12.278	1	12.278	0.162	.693	.011	.066	1061.691	14	75.835
Spatial Recall	7.102	1	7.102	0.244	.629	.017	.075	0.696	1	0.696	0.024	.879	.002	.052	407.773	14	29.127

* Type III Sum of Squares

Table H13

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Point 12 (n = 16)

	Model			*Model Statistics*				*Model Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	16.391	1	16.391	0.417	.529	.029	.092	54.587	1	54.587	1.387	.259	.090	.196	550.882	14	39.349
Word Recall	99.704	1	99.704	3.106	.100	.182	.375	66.689	1	66.689	2.077	.172	.129	.269	449.470	14	32.105
Nonword Recall	13.290	1	13.290	0.149	.706	.011	.065	3.294	1	3.294	0.037	.851	.003	.054	1251.228	14	89.373
Dot Matrix	25.899	1	25.899	0.370	.553	.026	.088	16.126	1	16.126	0.231	.638	.016	.073	978.874	14	69.920
Mazes Memory	468.409	1	468.409	3.482	.083	.199	.412	130.409	1	130.409	0.969	.342	.065	.151	1883.591	14	134.542
Block Recall	2.586	1	2.586	0.059	.811	.004	.056	6.143	1	6.143	0.141	.713	.010	.064	611.732	14	43.695
Listening Recall	164.525	1	164.525	2.660	.125	.160	.330	0.946	1	0.946	0.015	.903	.001	.052	865.929	14	61.852
Counting Recall	199.183	1	199.183	2.895	.111	.171	.354	11.694	1	11.694	0.170	.686	.012	.067	963.181	14	68.799
Backwards Digit	266.560	1	266.560	2.646	.126	.159	.329	0.006	1	0.006	0.000	.994	.000	.050	1410.213	14	100.729
Odd-One-Out	12.249	1	12.249	0.278	.606	.019	.078	118.855	1	118.855	2.694	.123	.161	.334	617.614	14	44.115
Mister X	26.092	1	26.092	0.354	.561	.025	.086	42.788	1	42.788	0.581	.459	.040	.110	1031.181	14	73.656
Spatial Recall	4.252	1	4.252	0.146	.708	.010	.065	0.130	1	0.130	0.004	.948	.000	.050	408.339	14	29.167

* Type III Sum of Squares

Table H14

Repeated Measures Analysis of Covariance of the AWMA Subtests Controlling for BAC Post-test (n = 16)

	Model			*Model Statistics*				*Interaction*			*Interaction Statistics*				*Error*		
	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*	*F*	*p*	$\eta^2_{Partial}$	*Power (1-β)*	*SS**	*df*	*Mean Square*
Digit Recall	46.116	1	46.116	1.581	.229	.101	.216	197.227	1	197.227	6.764	.021	.326	.677	408.241	14	29.160
Word Recall	106.168	1	106.168	3.466	.084	.198	.411	87.302	1	87.302	2.850	.114	.169	.350	428.857	14	30.633
Nonword Recall	0.830	1	0.830	0.009	.924	.001	.051	15.795	1	15.795	0.179	.679	.013	.068	1238.727	14	88.480
Dot Matrix	21.282	1	21.282	0.311	.586	.022	.082	36.782	1	36.782	0.537	.476	.037	.105	958.218	14	68.444
Mazes Memory	303.501	1	303.501	2.117	.168	.131	.273	6.644	1	6.644	0.046	.833	.003	.055	2007.356	14	143.383
Block Recall	4.496	1	4.496	0.104	.751	.007	.060	14.657	1	14.657	0.340	.569	.024	.085	603.218	14	43.087
Listening Recall	204.434	1	204.434	3.342	.089	.193	.399	10.381	1	10.381	0.170	.687	.012	.067	856.494	14	61.178
Counting Recall	370.759	1	370.759	5.515	.034	.283	.589	33.634	1	33.634	0.500	.491	.035	.101	941.241	14	67.232
Backwards Digit	283.862	1	283.862	2.818	.115	.168	.346	0.081	1	0.081	0.001	.978	.000	.050	1410.138	14	100.724
Odd-One-Out	1.314	1	1.314	0.027	.872	.002	.053	54.354	1	54.354	1.116	.309	.074	.166	682.115	14	48.722
Mister X	27.796	1	27.796	0.383	.546	.027	.089	58.337	1	58.337	0.804	.385	.054	.133	1015.632	14	72.545
Spatial Recall	6.650	1	6.650	0.228	.640	.016	.073	0.262	1	0.262	0.009	.926	.001	.051	408.207	14	29.158

* Type III Sum of Squares

Appendix I

Zero-order, Partial and Semi-partial Correlation Coefficients Between the Subtest Differences and Average BAC Controlling for Participant Age and "Stimulated"

Verbal Short-term Memory

Prior to formal analyses of covariance, correlational analyses between the mean differences and the identified covariates were studied. These consisted of zero-order, partial, and semi-partial, correlation coefficients integrated the three variables BAC, age at time of first assessment and "Stimulated". Table I1 shows the zero-order correlation coefficients between the repeated measures differences and the covariates for Verbal Short-term Memory.

Table I1

Zero-order Correlation Coefficients Between the Verbal Short-term Memory Subtest Differences to Average BAC, Participant Age and "Stimulated" (n = 16)

	Pearson's r			*Spearman's rho*		
	Average BAC	*Age*	*"Stimulated"*	*Average BAC*	*Age*	*"Stimulated"*
Digit Recall	.437	-.466	.160	.436	-.444	.044
p	.091	.069	.553	.091	.085	.871
Word Recall	-.301	.536*	-.330	-.311	.509*	-.399
p	.258	.032	.212	.241	.044	.126
Nonword Recall	.330	-.015	.004	.298	-.087	.125
p	.212	.955	.987	.262	.749	.646

* Significant at the 5% level

** Significant at the 1% level

Examination of Table I1 shows that larger than usual discrepancies are present between Pearson's *r* and Spearman's rho statistics for the "Stimulated" scale due to the nature of measurement. In the case of this scale only, Spearman's rho is preferred due to the ability to break tied ranks. Differences on the Digit Recall subtest were not statistically significantly correlated to average breath alcohol concentration ($r = .437$, $p = .091$). The positive correlation coefficient implies that higher readings of BAC are somewhat associated with tendencies towards deteriorations in performance under the experimental condition. Subjective feelings of being "Stimulated" towards the beginning of the assessment were not associated with the Digit Recall differences ($\rho = .044$, $p = .871$) but the close relationship between participant age and BAC was evidenced by a similar strength of correlation between age and the Digit Recall differences ($r = -.466$, $p = .069$) suggesting that younger persons, who tended towards higher

BAC readings, also tended towards deterioration in performance under experimental conditions. Unlike the Digit Recall correlation coefficients, the Word Recall differences were negatively correlated with average BAC (r = -.301, p = .258) and positively correlated with age (r = .536, p = .032). The interactions for Word Recall suggest that participant age may have been more strongly associated with changes in performance than average BAC was. The correlation coefficient between repeated measures differences on the Word Recall subtest and "Stimulated" was also inverse (ρ = -.399, p = .126), suggesting tendencies towards improvements in performance given higher levels of being "Stimulated" at the beginning of the assessment. The pattern returned to that seen for the Digit Recall subtest for Nonword Recall differences which were moderately correlated with average BAC (r = .330, p = .212) but weakly correlated with age of participant (r = -.015, p = .955) and "Stimulated" (ρ = .125, p = .646).

As the object of study, breath alcohol concentration was considered of primary importance in association with the test-retest differences. Therefore, the relationship to the differences between the repeated measures means for the Verbal Short-term Memory subtests was examined, separately, without the influences of participant age or "Stimulated" sensations. Partial correlation coefficients were conducted to remove the influence of the additional variables from both the difference scores and average BAC, while semi-partial, or part, correlation coefficients were used to control for the interaction between average BAC and the additional variable only. Table I2 and Table I3 show the zero-order, partial and semi-partial correlation coefficients removing the influence of participant age and the derived "Stimulated" scale respectively.

Table I2

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Verbal Short-term Memory Subtest Repeated Measures Differences Controlling for Participant Age (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Digit Recall	.437	.091	.230	.204	.409
Word Recall	-.301	.258	.016	.013	.956
Nonword Recall	.330	.212	.394	.394	.146

* Significant at the 5% level

** Significant at the 1% level

Table I2 shows a lack of statistically significant zero-order correlation coefficients between average BAC for Digit Recall subtest differences (r = .437, p = .091), Word Recall subtest differences (r = -.301, p = .258) or the Nonword Recall subtest differences (r = .330, p

= .212). Control for the variable "Age" through removal of its influence from both the subtest mean repeated-measures differences component and the BAC component resulted in a reduction in the strength of correlation coefficients for Digit Recall (r = .230, p = .409) and Word Recall (r = .016, p = .956) whilst the coefficient strength increased slightly for Nonword Recall (r = .394, p = .146). Removal of the influence of participant age from the BAC component only did not dramatically alter the correlation coefficients in comparison to the partial correlation coefficients for the Digit Recall (r = .204, p = .409), Word Recall (r = .013, p = .956) or Nonword Recall (r = .394, p = .146). The stability of the partial and semi-partial coefficients suggests an influence of age of participant on the BAC average component only. The reduction in magnitude of the correlation coefficients for the Digit Recall and Word Recall subtests after controlling for the influence of age suggests an impact of participant age on the relationship between the differences in means over the measures and BAC whilst this influence is not apparent for the Nonword Recall subtest. Therefore, for the Digit Recall, and Word Recall, subtests, the differences seen over the two conditions appear to be related to BAC with a strong influence from the variable "Age". This influence is evidently absent for the Nonword Recall. Control of the early assessment phase "Stimulated" scale showed similar changes for the Word Recall assessment but not the remaining sets of difference scores. These values are shown in Table I3 recalling that the zero-order coefficients represent the direct relationship between average BAC and the subtest differences as described earlier.

Table I3

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Verbal Short-term Memory Subtest Repeated Measures Differences Controlling for "Stimulated" (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Digit Recall	.437	.091	.417	.411	.122
Word Recall	-.301	.258	-.167	-.157	.552
Nonword Recall	.330	.212	.378	.378	.165

* Significant at the 5% level

** Significant at the 1 % level

Control for the "Stimulated" scale values in the relationship between average BAC and the Digit Recall assessment resulted coefficients which were similar to the zero-order magnitude (r = .437, p = .091) in the case of both the partial (r = .417, p = .122) and semi-partial (r = .411, p = .122) correlations. The stability suggests a lack of influence of the "Stimulated" early assessment portion scale. The same was true for the Nonword Recall assessment for the partial (r = .378, p = .165) and semi-partial (r = .378, p = .165) coefficients

in comparison to the zero-order correlation coefficient (r = .330, p = .212). However, the magnitude of coefficients decreased for the Word Recall subtest when controlled for "Stimulated" calculating a partial correlation coefficient (r = -.167, p = .552) and semi-partial coefficient (r = -.157, p = .552) in comparison to the zero-order correlation coefficient (r = -.301, p = .258). The reduction in the strength of correlation suggests an influence of "Stimulated" in explaining variance between average BAC and the differences seen in the mean values of Word Recall over the two assessment sessions. The stability of the partial and semi-partial coefficients suggests an influence of "Stimulated" from shared variance with average BAC only. The increase suggests a confounding influence of early subjective feelings of being "Stimulated" which may confound the relationship with average BAC levels.

Verbal Working Memory

Prior to comparisons of repeated measures means, zero-order, partial and semi-partial correlation coefficients were utilised to explore the relationships between the three covariates and the mean differences on each subtest assuming average BAC as the primary covariate or source of additional variance. Table I4 shows the Pearson's r and Spearman's rho correlation coefficients between the subtest difference scores and the three covariates.

Table I4

Zero-order Correlation Coefficients Between the Verbal Working Memory Subtest Differences to Average BAC, Participant Age and "Stimulated" (n = 16)

	Pearson's r			*Spearman's rho*		
	Avg BAC	*Age*	*Stimulated*	*Avg BAC*	*Age*	*Stimulated*
Listening Recall	.113	.223	.160	.125	.237	.056
p	.678	.407	.555	.645	.376	.836
Counting Recall	.239	-.032	.092	.171	-.089	.009
p	.373	.905	.735	.526	.744	.974
Backwards Digit	.175	.484	-.134	-.117	.576*	-.261
p	.516	.057	.620	.665	.019	.328

The Pearson's r and Spearman's rho correlation coefficients did differ in some cases. Due to the limited range of measurement of the "Stimulated" variable, as a sten scale with multiple tied ranks, Spearman's rho is also reported in those cases. For the other variables, Pearson's r is reported. Average BAC was not statistically significantly correlated with any of the Verbal Working Memory subtests. The Listening Recall subtest was weakly correlated with

average BAC (r = .113, p = .678). The Pearson's r value for the Counting Recall subtest was slightly larger (r = .239, p = .373). A similar magnitude of correlation coefficient was calculated for the Backwards Digit subtest in relation to average BAC (r = .175, p = .516), suggesting a lack of relationship between the repeated measures differences and average BAC as a covariate. Participant age, known to be statistically significantly correlated with average BAC (r = -.581, p = .018) but was not statistically significantly correlated with any of the subtest difference scores while the magnitude of the coefficients differed to those for the average BAC variable.

Weak correlation coefficients, lacking in statistical significance, were observed between participant age and differences over the repeated measures for the Listening Recall subtest (r = .223, p = .407) and Counting Recall subtest (r = -.032, p = .905). Although the Backwards Digit subtest differences were not strongly correlated to average BAC (r = .175, p = .516), the correlation with participant age was more substantial and approaching statistical significance for the Pearson's r calculations (r = .484, p = .057) whilst Spearman's rho was statistically significant (ρ = .576, p = .019). This finding suggested a unique relationship between participant age and changes over the repeated measures on the Backwards Digit subtest which is independent of average BAC values. For the "Stimulated" scale, measuring early congruence with feelings of stimulation on the B-BAES during the experimental assessment, the Spearman's rho values are reported given the limited range of measurement and frequency of tied ranks. As for the other two variables, no statistically significant correlation coefficients were present.

Feelings of being "Stimulated" early in the experimental assessment session were not statistically significantly correlated with repeated measures differences on the Listening Recall subtest (r = .160, p = .555; ρ = .056, p = .836), Counting Recall subtest (r = .092, p = .735; ρ = .009, p = .974) or Backwards Digit subtest (r = -.134, p = .620; ρ = -.261, p = .328). The inconsistency is reflected in the bidirectional correlation coefficients, with some being negative and others positive, thereby lacking clear direction of association between feelings of "Stimulated" early in the assessment and the Verbal Working Memory subtest differences.

The lack of statistically significant associations appears to confirm the lack of influence of general intoxication, both physiological and subjective. Average BAC was moderately correlated with the "Stimulated" scale (r = .496, p = .050), suggesting an interlinked relationship. For the Verbal Working Memory subtests, it appeared that subjective intoxication was not strongly linked to differences between the means over the repeated measures. Although the interaction effects between the outcome differences on the AWMA Verbal Working Memory subtests and the three identified covariates, or potentially causative variables, were

not statistically strong, further exploration was required in identifying true differences across the sessions. Prior to formalised analysis of the differences in means, participant age and "Stimulated" are further considered as covariates via partial and semi-partial correlation coefficients to assess the true relationship between average BAC and the differences over the two conditions on each subtest and processing score.

Table I5 shows the zero-order, partial and semi-partial correlation coefficients calculated between average BAC and the Verbal Working Memory subtest when participant age is accounted for.

Table I5

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Verbal Working Memory Subtest Repeated Measures Differences Controlling for Participant Age (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Listening Recall	.113	.678	.305	.297	.269
Counting Recall	.239	.373	.270	.270	.330
Backwards Digit	.175	.516	.641	.561	.010

* Significant at the 5% level

** Significant at the 1 % level

Table I5 shows substantial increases in the magnitude of the partial, and semi-partial, correlation coefficients when compared to the zero-order relationship between average BAC and the difference scores. Removal of the influence of participant ages from both the average BAC, and difference, components resulted in a similar correlation coefficient to the semi-partial version accounting for associations between participant age and average BAC only. This finding suggests that participant age is similarly related to the difference score, and average BAC. At the zero-order level, average BAC and the Listening Recall subtest were not strongly correlated (r = .113, p = .678), but the magnitude increased in a positive direction when the influence of participant ages was removed from both variables as a partial correlation (r = .305, p = .269), and from average BAC only as a semi-partial correlation (r = .297, p = .269). However, the correlation coefficients between the differences on the Counting Recall subtest and average BAC (r = .239, p = .373) were not strongly influenced by participant age, maintaining a similar magnitude for the partial correlation coefficient (r = .270, p = .330), and semi-partial correlation coefficient (r = .270, p = .330). This finding indicates that participant age was not influential in the differences over the repeated measures for the Counting Recall subtest. The Backwards Digit subtest was the most strongly influenced by participant ages, where a weak zero-order correlation coefficient was evident (r = .175, p = .516) as opposed to

a considerably larger partial correlation coefficient (r = .641, p = .010), and semi-partial correlation coefficient (r = .561, p = .010). Whilst the removal of the influence of participant age seemed to strengthen the association between average BAC and subtest differences, removal of the influence of "Stimulated" either had little effect, or weakened the associations slightly, as shown in Table I6.

Table I6

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Verbal Working Memory Subtest Repeated Measures Differences Controlling for "Stimulated" (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and semi-partial p*
Listening Recall	.113	.678	.039	.039	.890
Counting Recall	.239	.373	.223	.222	.423
Backwards Digit	.175	.516	.281	.279	.309

* Significant at the 5% level

** Significant at the 1 % level

The zero-order correlation coefficient between differences on the Listening Recall assessment and average BAC (r = .113, p = .678) weakened when the influence of "Stimulated" was removed from both variables (r = .039, p = .890) or just average BAC (r = .039, p = .890). However, the Counting Recall zero-order correlation coefficient to average BAC (r = .239, p = .373) was stable after the influence of "Stimulated" was removed partially (r = .223, p = .423) and semi-partially (r = .222, p = .423). The relationship between average BAC and differences on the Backwards Digit subtest at the zero-order (r = .175, p = .516) was magnified by the removal of "Stimulated" from both variables (r = .281, p = .309) or only average BAC (r = .279, p = .309). Bearing in mind that "Stimulated" was moderately correlated with average BAC (r = .497, p = .050), the Backwards Digit subtest responded in a manner indicative of a true influence of BAC without the confounding influence of subjective intoxication. However, the Listening Recall subtest did not reflect the expected change in relationship whilst no influence appeared to be present for the Counting Recall component. Although inconsistencies were present, the findings indicate that it is possible that "Stimulated" did not strongly influence the relationship between differences seen on the repeated measures of the subtest and average BAC, excepting for the Backwards Digit subtest. The lack of statistical influence suggests that no fusion of relationship was statistically present.

Visuo-spatial Short-term Memory

Interactions were explored further by way of partial, and semi-partial, correlation coefficients excluding these influences from the relationship between average BAC and differences on the subtest performances. Table I7 shows the zero-order correlation coefficients between differences on the Visuo-spatial Short-term Memory subtests and the three covariates.

Table I7

Zero-order Correlation Coefficients Between the Visuo-spatial Short-term Memory Subtest Differences to Average BAC, Participant Age and "Stimulated"

	Pearson's r			Spearman's rho		
	Average BAC	Age	"Stimulated"	Average BAC	Age	"Stimulated"
Dot Matrix	-.173	.130	.198	-.184	.152	.071
p	.523	.632	.463	.494	.575	.794
Mazes Memory	-.040	.001	.127	-.100	.058	.179
p	.884	.997	.640	.713	.832	.507
Block Recall	.232	.210	-.057	.259	.178	-.101
p	.387	.434	.833	.333	.510	.710

* Significant at the 5% level

** Significant at the 1 % level

Some incongruence was noted between the Pearson's *r* and Spearman's rho correlation coefficients, predominantly for the "Stimulated" scale. Average BAC was weakly, and not statistically significantly, correlated with the difference values on the Dot Matrix subtest (r = -.173, p = .523), Mazes Memory subtest (r = -.040, p = .884) and Block Recall subtest (r = .232, p = .387). The direction of the correlation coefficients varied providing no clear indication of an influence of average BAC on differences over the repeated measures sessions.

Participant age was positively correlated with the subtest difference scores, implying that participants who were older at the time of the first assessment tended towards deteriorations in performance under the experimental condition. However, the correlation coefficients were weak, and not statistically significant, for differences on the Dot Matrix subtest (r = .130, p = .632), Mazes Memory subtest (r = .001, p = .997) and Block Recall subtest (r = .210, p = .434). For both average BAC and participant age, stronger correlation coefficients were evident in relation to the difference score on the Block Recall subtest in comparison to the remaining two subtests. However, this was not true of the "Stimulated" scale.

The "Stimulated" scale, measuring congruence with subjective perceptions of stimulation on the B-BAES over points one through four of the experimental assessment, was not statistically significantly correlated with the Dot Matrix subtest (r = .198, p = .463), Mazes

Memory subtest (r = .127, p = .640)or Block Recall subtest (r = -.057, p = .833). Average BAC was correlated with both participant age (r = -.581, p = .018) and the "Stimulated" scale (r = .497, p = .050) implying that younger participants tended towards higher average breath alcohol concentrations which were also associated with higher subjective reports of "Stimulated" early in the assessment. Furthermore, younger participants were more inclined to report feelings of being "Stimulated" early in the assessment (r = -.517, p = .040). Therefore, control of the two covariates, participant age and "Stimulated", with regards to the relationship between average BAC and differences over the repeated measures was also necessary. However, first, the covariate participant age was considered linearly. The zero-order, partial and semi-partial correlation coefficients are presented in Table I8.

Table I8

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Visuo-spatial Short-term Memory Subtest Repeated Measures Differences Controlling for Participant Age (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Dot Matrix	-.173	.523	-.121	-.120	.669
Mazes Memory	-.040	.884	-.048	-.048	.865
Block Recall	.232	.387	.445	.435	.096

* Significant at the 5% level

** Significant at the 1 % level

The Dot Matrix subtest was not statistically significantly correlated with average BAC at the zero order (r = -.173, p = .523) and similar magnitudes of correlation coefficient were seen when participant age was controlled for. The partial correlation coefficient between average BAC and differences on the Dot Matrix controlling for participant age in both variables was not statistically significant (r = -.121, p = .669), nor was the semi-partial correlation coefficient removing the influence of participant age from the average BAC component only (r = -.120, p = .669). The congruence between the partial and semi-partial coefficients suggests an association between participant age and average BAC only, excluding an influence of age on the Dot Matrix differences as supported by the original association (r = .130, p = .632). Similarly, removal of the influence of participant age from the relationship between average BAC and the Mazes Memory subtest did not result in a considerable change in the magnitude of the partial correlation coefficient (r = -.048, p = .865), or semi-partial correlation coefficient (r = -.048, p = .865), in comparison to the zero-order correlation coefficient (r = -.040, p = .884). Differences on the Block Recall subtest were not strongly associated with average BAC (r = .232, p = .387), although the correlation coefficient was somewhat stronger than those of

the other two subtests. Removal of the influence of participant age from both variables within the relationship resulted in a considerable increase in the correlation coefficient (r = .445, p = .096) which remained stable when the influence of participant age was removed from the average BAC component only as a semi-partial correlational relationship (r = .435, p = .096). The relationships suggest the potential for linear interactions with participant age as a covariate in a model comparing the repeated measures of Block Recall, suggesting an attenuating effect of the negative relationship between average BAC and participant age (r = -.581, p = .018). The influence of participant age on the linear relationship between average BAC and differences in performance on each of the repeated measurements of the Visuo-spatial Short-term Memory subtest seemed most substantial for the Block Recall subtest. This was shown by a considerable increase in the strength of association between average BAC and the difference value when the influence of participant age was removed. This type of change also occurred when variance introduced by the "Stimulated" scale was controlled for. The zero-order, partial and semi-partial correlation coefficients controlling for "Stimulated" in the relationship between average BAC and the Visuo-spatial Short-term Memory subtests, and composite score, are shown in Table I9.

Table I9

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Visuo-spatial Short-term Memory Subtest Repeated Measures Differences Controlling for "Stimulated" (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Dot Matrix	-.173	.523	-.318	-.312	.247
Mazes Memory	-.040	.884	-.119	-.118	.673
Block Recall	.232	.387	.301	.300	.276

* Significant at the 5% level

** Significant at the 1 % level

The weak negative correlation between the Dot Matrix subtest differences and average BAC (r = -.173, p = .523) increased in absolute magnitude when a partial correlation coefficient was used to eliminate the influence of "Stimulated" from both variables (r = -.318, p = .247), and when a semi-partial correlation coefficient was calculated to remove the influence of "Stimulated" from average BAC alone (r = -.312, p = .247). Unlike the other subtests, the negative relationship suggests that higher values of average BAC, also associated with higher congruence with "Stimulated" (r = .497, p = .050), were associated with a tendency towards improvements in scores, rather than deteriorations in performance. This should be interpreted in context of the actual difference score values.

The absolute magnitude of the partial, and semi-partial, correlation coefficients was also greater than that of the zero-order correlation coefficient between average BAC and the Mazes Memory subtest differences (r = -.040, p = .884) when "Stimulated" was controlled for. Controlling for "Stimulated", both the partial correlation coefficient (r = -.119, p = .673), and semi-partial correlation coefficient (r = -.118, p = .673) were weak and negative, implying a slight tendency towards improvements in performance under the experimental condition associated with greater congruence with "Stimulated". The interactions were not statistically significant (p > .05) and are explored further as part of the analysis of covariance models. Meanwhile, the Block Recall subtest difference associations were positive, implying tendencies towards deteriorations in performance associated with higher feelings of "Stimulated".

The Block Recall subtest differences correlations with average BAC were positive for the zero-order correlation coefficient (r = .232, p = .387) and controlling for "Stimulated" when a partial correlation coefficient was calculated (r = .301, p = .276), and when a semi-partial correlation coefficient was calculated (r = .300, p = .276). The findings imply a minimal influence of "Stimulated" on the relationship between differences on the Block Recall subtest over the repeated measures and average BAC. The influence appeared to be confined to the association between average BAC and "Stimulated" only, without an interaction between "Stimulated" and the difference score. In general, tendencies towards deteriorations in performance were somewhat associated with lower average BAC values rather than higher average BAC readings and "Stimulated" played a small role in altering this relationship.

Visuo-spatial Working Memory

Correlational analyses, focusing on zero-order, partial and semi-partial coefficients, provided valuable information regarding the interrelationships of the covariates with differences over the repeated measures of the Visuo-spatial Working Memory subtests. Table I10 shows the correlation coefficients calculated between the subtest differences and covariates. The covariates test-retest delay and RPM are included in Table I10 but only reflected as applicable in the creation of the analysis of covariance model.

Table I10

Zero-order Correlation Coefficients Between the Visuo-spatial Working Memory Subtest Differences to Average BAC, Participant Age and "Stimulated"

	Pearson's r			*Spearman's rho*		
	Average BAC	*Age*	*"Stimulated"*	*Average BAC*	*Age*	*"Stimulated"*
Odd-one-out	-.359	.561*	-.389	-.497	.587*	-.252
p	.172	.024	.137	.050	.017	.346
Mister X	.069	.455	-.236	.119	.433	-.052
p	.800	.077	.379	.662	.094	.848
Spatial Recall	.014	-.023	-.050	.063	.009	-.022
p	.958	.933	.854	.816	.974	.934

* Significant at the 5% level

** Significant at the 1 % level

Table I10 shows the correlation coefficients between the repeated measures differences on each of the Visuo-spatial Working Memory subtests and the identified covariates. Limited inconsistencies were noted between the Pearson's *r* and Spearman's rho correlation coefficient values and statistical significance levels. Average BAC was not statistically significantly correlated with repeated measures differences on the Odd-one-out subtest (r = -.359, p = .172), Mister X subtest (r = .069, p = .800) or Spatial Recall subtest (r = .014, p = .958). The absence of statistically significant correlation coefficients implies an absence of a linear regression effect of average BAC as a covariate in the model differences. The Odd-one-out subtest evidently responded in the opposite manner to that expected, indicating that lower average BAC readings were associated with improvements in performance rather than deteriorations. The remaining subtests showing correlation coefficients of stronger than an absolute magnitude of $r = \pm.100$ also demonstrated this negative coefficient trend.

Participant age was statistically significantly correlated with repeated measures differences on the Odd-one-out subtest (r = .561, p = .024). The positive direction of the correlation coefficients suggests a tendency towards deterioration in performance under the experimental condition with increased age, a trend consistent with the other AWMA subtests examined. Moderate positive, but not statistically significant, correlation coefficients were also calculated between participant age and repeated measures differences on the Mister X subtest, which approached statistical significance, (r = .455, p = .077). However, close to zero correlation coefficients were observed between participant age and differences on the Spatial Recall subtest (r = -.023, p = .933) indicating some differential functioning of this subtest in relation to age.

Correlations between the repeated measures differences and the "Stimulated" scale followed a similar pattern of negative correlation coefficients evidenced by average BAC. None of the correlations were statistically significant but negative correlation coefficients of some substance were observed for the Odd-one-out subtest (r = -.398, p = .137) and Mister X subtest (r = -.236, p = .379). Like that for participant age, a weak correlation coefficient was observed for the Spatial Recall subtest (r = -.050, p = .854).

With average BAC being considered the primary influence, each of the covariates was also examined for its influence on the repeated measures difference to average BAC relationship. Partial correlation coefficients were used to determine differences should the influence of the covariate be removed from both variables whilst semi-partial correlation coefficients were examined to determine the influence of the removal of the covariate from the average BAC variable alone. In most cases, consistency between the partial and semi-partial correlation coefficients indicated the association of the additional covariate in relation to average BAC alone, with minimal contribution to variance on the difference score per subtest or processing score. Table I11 present the zero-order, partial and semi-partial correlation coefficients for the relationship between average BAC and the differences on the Visuo-spatial Working Memory subtests exclusive of the influence of participant age, known to be strongly correlated to average BAC (r = -.581, p = .018). The exploration of the partial and semi-partial correlation coefficients elucidates upon the interaction effects described later.

Table I11

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Visuo-spatial Working Memory Subtest Repeated Measures Differences Controlling for Participant Age (n = 16)

	Zero-order	*Zero-order p*	*Partial Coefficient*	*Semi-partial Coefficient*	*Partial and Semi-partial p*
Odd-one-out	-.359	.172	-.050	-.042	.859
Mister X	.069	.800	.459	.409	.085
Spatial Recall	.014	.958	.002	.002	.996

* Significant at the 5% level

** Significant at the 1 % level

The zero-order correlation coefficient between average BAC and the repeated measures differences on the Odd-one-out subtest (r = -.359, p = .172) was considerably larger than the partial correlation coefficient excluding the influence of participant age (r = -.050, p = .859), or the associated semi-partial correlation coefficient (r = -.042, p = .859). The drop in the strength of association suggests that participant age may have been an explanatory factor of the variance in the relationship resulting in a lack of relationship once its influence was removed.

The Mister X subtest relationship with average BAC was weak (r = .069, p = .800) but dramatically increased when participant age was partialled out (r = .459, p = .085). The semi-partial correlation coefficient was also consistent (r = .409, p = .085). The partial, and semi-partial, correlation coefficient suggests an extreme attenuating influence of participant age. Once this influence was removed, a stronger relationship between the repeated measures differences and average BAC was evident, implying that individuals recording higher average BAC readings also tended towards deteriorations in performance on the Mister X subtest. Although participant age seemed to have an attenuating effect, producing negative associations between average BAC and the repeated measures differences, removal of the variance produced by this covariate did not appear to impact associations for the Spatial Recall Processing subtest and processing score which was not correlated with average BAC (r = .014, p = .958) and the association did not strengthen when participant age was accounted for using a partial correlation coefficient (r = .002, p = .996), or semi-partial correlation coefficient (r = .002, p = .996).

Participant age appeared to have an attenuating influence on the relationship between the repeated measures differences and average BAC for the Visuo-spatial Working Memory subtests. In some cases, notably for the Mister X components, removal of the influence of participant age resulted in the expected moderate, positive, correlation between average BAC and the differences over the two measures, implying a tendency towards deteriorations in performance given higher average BAC readings. Although average BAC and the “Stimulated” scale, reflecting congruence with the B-BAES items measuring subjective stimulation over points one through four in the assessment, were moderately correlated (r = .497, p = .050), removal of the influence of “Stimulated” from the relationship between the repeated measures differences and average BAC for the Visuo-spatial Working Memory subtests did not have the same impact as the removal of “Age”. Table I12 shows these zero-order, partial and semi-partial correlation coefficients and associated significance levels.

Table I12

Zero-order, Partial and Semi-partial Correlation Coefficients Between Average BAC and the Visuo-spatial Working Memory Subtest Repeated Measures Differences Controlling for "Stimulated" (n = 16)

	Zero-order	Zero-order p	Partial Coefficient	Semi-partial Coefficient	Partial and Semi-partial p
Odd-one-out	-.359	.172	-.208	-.192	.457
Mister X	.069	.800	.220	.214	.430
Spatial Recall	.014	.958	.045	.045	.873

* Significant at the 5% level

** Significant at the 1 % level

The repeated measures differences on the Odd-one-out subtest, excluding the influence of "Stimulated", were negatively correlated to average BAC (r = -.208, p = .457). The semi-partial correlation coefficient controlling for "Stimulated" was also consistent (r = -.192, p = .457). Although negative, some change was evident in comparison to the zero-order correlation coefficient between the repeated measures difference and average BAC (r = -.359, p = .172). Nonetheless, the data implies that higher average BAC readings may be somewhat associated with tendencies towards improvements in performance on the Odd-one-out subtest, rather than deteriorations. Like that for the variable "Age", the zero-order correlation coefficient between repeated measures differences on the Mister X subtest and average BAC (r = .069, p = .800) was substantially lower than the correlation coefficient when "Stimulated" was partialled out (r = .220, p = .430). The semi-partial correlation coefficient was consistent in this case (r = .214, p = .430). The change implies an attenuating influence of "Stimulated" in the correct relationship between the repeated measures differences and average BAC on the Mister X subtest. However, the repeated measures differences on the Spatial Recall subtest were not correlated with average BAC at the zero-order (r = .014, p = .958), or after removal of the influence of "Stimulated" based on a partial correlation coefficient (r = .045, p = .873) and semi-partial correlation coefficient (r = .045, p = .873). The covariate "Stimulated" did seem to have some influence on the relationship between the repeated measures differences on the Visuo-spatial Working Memory subtest and average BAC. As was also found for participant age, the most dramatic effect was seen for the Mister X subtest differences.

For all the AWMA subtests, the correlational control of the interrelated covariates, participant age and "Stimulated", on the relationship between average BAC and the repeated measures differences resulted in differential responses. In most cases, when participant age was controlled for, the correlation coefficients tended in an opposite direction, resulting in a weaker

negative correlation in some cases. The influence of “Stimulated” on this relationship was not as substantial, although some changes were observed.