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Assessment of Verbal and Nonverbal Memory and Learning in Abstinent Alcoholics

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ALYSON L. PHELAN

ABSTRACT

Neuropsychological performance was measured in chronic alcoholics who maintained abstinence for at least six months and with matched controls. Specifically, measures of verbal memory were assessed utilizing the Rey Auditory Verbal Learning Test (RAVLT) and measures of nonverbal memory with the Rey Osterreith Complex Figure Test (ROCF) and a new measure, the Poreh Nonverbal Memory Test (PNMT). In addition, both the RAVLT and the PNMT provide a measure of operationalized learning, as they are multi-trial tasks utilizing five trials to assess recall in each trial. Verbal memory includes the ability to encode, store and retrieve information for words, language and verbal stimuli. Nonverbal memory reflects the ability to encode, store and retrieve information that is visual and spatial in nature. It is devoid of verbal components and includes abstract designs or nonsense figures. Currently, there are questions as to the validity of many nonverbal memory measures because they allow for sub-vocalization of the tasks thereby utilizing verbal mediation (Wisniewski, Wendling, Manning & Steinhoff, 2012). The present study assessed for differences in verbal and nonverbal memory in abstinent alcoholics and predicted that they would perform more poorly on nonverbal measures while verbal memory would remain intact. Additionally, a comparison of learning curves was examined for each group. Finally, the PNMT was validated by correlating with a current neuropsychological assessment of memory and learning, the RAVLT, and a nonverbal neuropsychological assessment, the ROCF.

Results indicated that the abstinent alcoholics differed significantly in nonverbal measurements depending upon the complexity of the tasks. Concerning verbal tasks, there was no significant difference in results across the groups. However, the length of alcohol dependence did significantly predict performance on the RAVLT recognition task indicating possible frontal lobe deficits and disordered recall. Correlational analyses indicate that the utility and validity of the new visual-spatial memory test, the PNMT, is consistent with the ROCF for nonverbal memory and the RAVLT as a learning assessment for verbal memory and learning. Further, the PNMT is not affected by education as is the ROCF and RAVLT. Together, these results showed that nonverbal memory was impaired in abstinent alcoholics despite length of abstinence and verbal memory remained relatively intact. Additionally, the PNMT is a valid measure of nonverbal memory and learning.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

1.1 Background and Purpose

Alcohol abuse is one of the most common types of drug abuse in the Western hemisphere (Crego et al., 2010). Chronic alcoholism leads to brain damage and cognitive deficits including effects on episodic memory, which includes encoding, storage and retrieval of personally experienced events in their spatial and temporal context (Pitel, Rivier, Beaunieux, Vabret, Desgranges & Eustache, 2009). In particular, verbal and nonverbal memory have been shown to be particularly affected following alcohol dependence and have been a main area of study. However, the extent of normalization of these memory processes following cessation of chronic and heavy consumption remains unclear (Pitel et al., 2009).

The following study investigated the impact of abstinence from alcohol on verbal and nonverbal memory in a group of abstinent alcoholics to determine if they differed from controls. Measuring these aspects of neuropsychological functioning both early in recovery and in later years may become a critical aspect to treatment in abstinent

alcoholics. Intervention plans for this group may need to be altered in treatment facilities and by those providing psychotherapy in accordance with deficits that may persist following abstinence in order to best support recovery and prevent relapse. Higher levels of cognitive functioning in patients have been shown to be associated with successful inpatient treatment, fewer relapses, and the ability to maintain abstinence over longer periods (Davies et al., 2005). In addition, new neuropsychological assessments that are less affected by level of education may prove to aid clinicians in understanding the impact of alcohol dependency on cognitive functioning in recovering alcoholics despite educational background as many addicts forgo education in pursuit of their addiction. This may enable them to provide appropriate interventions for successful recovery.

1.2 Cognitive basis of memory

Ebbinghaus (1885) was a pioneer in the study of memory and his work began an era known as "verbal learning" in relation to memory. This era emphasized the ability to measure paired-association of verbal lists of words and serial learning processes as a way to assess memory. Following this era was a 'Golden Age' of memory research beginning in the 20th century (Moscovitch et al., 2005a). Research then focused on the temporal nature of how memories are processed by the brain. It is currently known that memory is a complex method on which stimuli or events are processed and stored by the brain for future use. It includes encoding, storage and retrieval for both short-term and long-term use. Many neural mechanisms are involved in memory and this is why it is a complex system. Various models exist as to the nature of memory, however there is some agreement concerning the major components in current memory models.

One theory of non-unitary memory divides long-term memory into two forms known as explicit, or declarative, and implicit, or non-declarative (Squire, 2004). These memory types can last from days to an entire lifetime. Explicit and implicit memory are concerned with diverse variables ruled by different principles each involving distinctive materials. These are mediated by individual neural structures and mechanisms that form these dissociable systems (Moscovitch, 2005a). They distinguish between conscious recollection of facts, general knowledge and personal experiences (explicit) and unconscious learning (implicit) (Henke, 2010). Intentional memory of previous experiences describes explicit memory. Unintentional memory caused by the effects of previous experiences without awareness describes implicit memory. Another way to consider types of memory includes two facets: (a) intentional recall of recently presented information that is part of explicit memory and includes facts and events, and (b) unintentional recall of previously presented recent information that is part of implicit memory and includes priming, procedural skills and habits, classical and operant conditioning, and non-associative learning (Kirchner & Sayette, 2003).

Explicit memory is typically divided into two subtypes: episodic and semantic. Episodic memory involves particular autobiographical events including the content as well as the spatial and temporal context of the event. This is the type of memory that allows one to mentally relive the experience (Tulving, 1985). To assess episodic memory, neuropsychologists use recall and recollection testing to determine conscious awareness of the experience of the patient. Semantic memory involves the absence of the context of the experience and refers to the knowledge acquired during the memory formation. This type of memory involves the long-term concepts, facts and meanings for

instance, as well as personal facts or *personal semantics* (Kopelman, Wilson & Baddeley, 1989). It does not involve the sense of the experience of the memory formation.

Implicit memory includes perceptual priming, procedural memory and conditioning. Perceptual priming involves the ability to perceive a picture or face more quickly after having viewed it previously. Procedural memory, however, involves learning a motor sequence without conscious awareness of learning it such as riding a bike. Conditioning, in comparison, is learning to form a response based on prior conditioning without conscious awareness of the reason for the response (Schacter, 1987).

There are numerous challenges in understanding the processing of implicit memories. Korsakoff (1889) described an amnesic syndrome, now known as Korsakoff's Syndrome, that included patients being unaware of preserved memory traces from events without a contextual sense and yet they behaved unconsciously based on an idea perceived during the event. Additionally, research involving amnesics shows that the ability to perform normally on short-term memory tasks is intact, yet indicates deficits on long-term verbal memory tasks. However, recall of implicit memory tasks is also intact (Roediger III, 1990). Research continues to further knowledge of implicit memory.

Additionally, encoding, storage and retrieval are essential to short-term or working memory function. Encoding involves the initial exposure to and interpretation of a stimulus. Storage involves the consolidation and maintenance of a stimulus. Retrieval is the process of the search and recovery of a stimulus (Lee, Roh, & Kim, 2009). Additionally, it is thought that the brain functions via a parallel processing system (Henke, 2010) which is mediated by the fact that there are two hemispheres, a

right and left. This parallel system allows for faster and more effective consolidation, as well as provides redundancy in the case of damage to the areas of the brain that process memory. Another distinction is the difference between recall (an active search process for a specific piece of data) and recognition (ability to correctly identify information previously learned from a list). Working memory has a limited capacity for retaining information and typically lasts for a few seconds as research has supported via the word-length effect (Kociuba, 2011). This effect was examined by Baddeley, Thompson & Buchanan (1975) by having subjects read five, one-syllable words and five, five-syllable words. Recall of the shorter words was better than recall of the longer words. This revealed that the time the brain utilizes to process information inhibits the brain's ability to incorporate additional information and convert it to long-term memory.

Methods of encoding memory also include the mechanism utilized for processing of the stimuli. Historically, differences in episodic memory processing are suggested to include verbal and nonverbal aspects of encoding. The verbal mechanism is mediated semantically by labeling objects and then subvocally rehearsing the name in an articulatory loop (Zelinsky & Murphy, 2000). This is known as verbal memory. An alternate form of memory is nonverbal memory and includes the processing of visual stimuli and their spatial relationship. These two types of memory seldom act alone in stimuli processing and subsequent encoding. However, the speed at which the visual system functions is faster than the speed at which the subvocal system functions (Zelinsky & Murphy, 2000). This means the systems have to synchronize for stimuli that appeal to both mechanisms. These systems also are measured independently for assessment of each function.

1.3 Neuroanatomical basis of memory

Neuroanatomically, there are two systems of neural substrates concerning memory proposed by Eichenbaum, Otto, & Cohen (1994) and Aggleton & Brown (1999). The first contains the hippocampus and its connections to the mammillary bodies and anterior thalamic nuclei which mediates recollection relying on relational information with temporal-spatial context of memories. Resulting deficits include spatial and relational memory concerning autobiographical episodes. The second system consists of the perirhinal cortex (PRC) and its connections to the dorsomedial nucleus of the thalamus, which mediates object recognition based on familiarity, but not spatial-temporal context. Damage to this system results in impaired recognition of a single object (Aggleton et al., 2000).

Semantic memory does not depend on medial temporal and diencephalic structures beyond possibly encoding. It depends upon posterior and anterior neocortical structures that are dependent on the type of memory and include the lateral and anterior temporal cortex and ventro-lateral prefrontal cortex (Moscovitch et al., 2005a). Bilateral damage to the medial temporal lobe structures have been shown to impair the ability of the brain to form new memories and it impairs the recall of events, facts and autobiographical experiences that were stored before the impairment occurred (Eichenbaum, 2001, Squire, Stark & Clark, 2004).

There are two commonly accepted models of memory consolidation. The standard model attributes memory formation as beginning when information is registered in the neocortex and is integrated by the hippocampal complex/medial temporal lobes (HC/MTL) as well as other structures within the diencephalon (Squire & Alarez, 1995).

This forms a memory trace that is comprised of hippocampal and neocortical neurons thought to form an index representing the content of the event as well as the conscious experience of it (Moscovitch, 1995). The consolidation and formation is rapid and can last from seconds to days and is called *rapid* or *synaptic consolidation* (Moscovitch, 1995). This rapid consolidation is then followed by a prolonged consolidation, which can last from months to years and is known as *prolonged* or *system consolidation* (Dudai, 2004; Frankland & Bontempi, 2005). The HC/MTL as well as related structures are necessary for storage and retrieval of the memory trace until the neocortex and/or other hippocampal structures can act alone in sustaining the memory trace and accommodating the retrieval (Moscovitch et al., 2005a). This model proposes that the HC/MTL are temporary memory structures. This would implicate the hippocampal structure and neocortical storage site linkage as necessary for memory consolidation, but also posits that time eliminates the need for such linkage (Nadel, Samsonovich, Ryan & Moscovitch, 2000). The hippocampal functional change is an explanation for retrograde amnesia (loss of memory for a period prior to the onset of amnesia) following hippocampal damage (Lezak, Howieson, & Loring, 2004, p. 28).

A second model of memory consolidation proposed by Nadel and Moscovitch (1997) is called the multiple trace theory (MTT) and this argues that the HC, and possibly the diencephalon, "rapidly and obligatorily" encode all conscious events and binds the neocortical neurons that represent the experience into a memory trace as previously mentioned. This model eliminates the prolonged consolidation process that proposes an enhancement of the memory trace and instead proposes the creation of a new memory trace each time the memory is retrieved, thus they are less susceptible to memory

disturbance due to brain damage. In other words, the longer the memory for an event has been stored, and the more it has been retrieved, the less chance of the loss of the memory of the event due to an injury. This is based on research that supports the view that there is a difference with respect to the type of memory loss in retrograde amnesia as well as the extent and duration of the loss with regard to HC/MTL damage (Nadel & Moscovitch, 1997). Autobiographical episodic memories are typically most affected by HC/MTL damage, however semantic memories can withstand damage to the hippocampal structures if it has been encoded in the neocortex and a sufficient amount of time has passed (Moscovitch, 2004). Nadel et al. (2000) conducted a neuroimaging study that indicated the hippocampus was activated for memories formed as long as 25 years prior to the study as compared to recent memories. Thus, retrograde amnesia can be present for decades, which is longer than a biological consolidation process would last (Moscovitch et al, 2005a).

Scoville & Milner (1957) began the era of research into the effects of damage to the MTLs with a study showing the results of bilateral damage causing chronic anterograde amnesia. Anterograde amnesia involves the loss of the ability to encode new memories following the occurrence of injury. Further research has suggested that various subregions of the MTL contribute differently to parts of explicit memory and recognition memory. Anatomically, the hippocampi are connected to the perirhinal and prefrontal cortices. Barker & Warburton (2011) found that the hippocampus is crucial for object location (changing the location of an object that was previously seen), object-in-place (switching 2 of 4 objects locations) and recency recognition (recalling an object that was most recently seen) memory performance in animals. They further found that object-in-

place and recency recognition memory are dependent upon either the perirhinal or medial prefrontal cortices. This implies that remembrance of a stimulus that happened in a certain place or object recency, involves functional interaction between the hippocampus and medial prefrontal cortices or perirhinal cortices (Barker & Warburton, 2011). Aggleton & Brown (1999) proposed that recognition memory is a two component process – one being recollective, which is supported by the hippocampus, and one that is familiarity or automatic based, which is supported by the PRC, with each functioning from a different area of the MTL.

When considering encoding and retrieval of episodic memory consciously, Moscovitch (2004) contends that the involvement of the hippocampus is automatic, however there is some control over what we encode and retrieve from memory. Moscovitch attributes this to involvement from the frontal lobes as a companion-type system that controls the information sent to the medial temporal lobes upon encoding, possibly orchestrating retrieval as well. Various brain-imaging studies support the hypothesis. A review by Buckner, Kelley & Petersen (1999) of frontal lobe memory involvement found that positron emission tomography (PET) and functional magnetic resonance imaging (fMRI) indicate areas within the left frontal cortex are active with intentional memorization of words and the right frontal cortex for intentional memorization of faces. Further, studies show that the level of activity in the frontal cortex essentially predicts the likelihood that the stimuli are later remembered (Buckner et al., 1999). Additionally, Buckner et al. (1999) noted that there are differences in the types of stimuli with regard to context and recognition that are remembered following damage to the frontal lobes in accordance with Moscovitch's memory trace theory.

Recently, research has indicated the involvement of the parietal cortex in episodic memory. Cabeza, Ciaramelli, Olson & Moscovitch (2008) reviewed the research pertaining to the parietal lobe and point out that lesions to the parietal lobe do not typically result in severe episodic memory deficits. However, in neuroimaging studies, parietal activations are common. This may be primarily due to the connectivity of the MTL to the parietal cortex and the frontal cortex. Olson & Berryhill (2009) indicate the connectivity between the inferior parietal lobe, the MTL and the superior and inferior parietal regions may play an important role in the processing of visual memory. Further, they indicate parietal activation for old memories is greater than for new items. Kim & Cabeza (2007) studied a "top-down" and "bottom-up" effect for episodic memory in parietal activation with superior parietal regions being activated for low confidence responses (unsure of old vs. new episodic memories) and high confidence responses (sure of old vs. new episodic memories). This is indicative of episodic memory retrieval demands and the role as a possible "buffer" (a type of working memory) or memory confidence (Baddeley, 2000). Memory retrieval is not lessened by parietal lobe damage but perhaps a "sub-process" for specific tasks is involved (Olson & Berryhill, 2009). One hypothesis is that the more confident the response, the more demands that are placed on the "buffer", but this does not explain why posterior parietal cortex (PPC) damage leads to various levels of memory performance dependent upon the probe task (Cabeza, 2008). Other hypotheses include PPC assessment to determine if a stimulus was previously viewed (Wagner, Shannon, Kahm & Buckner, 2005), the role of the PPC in attention as well as memory (Cabeza, 2008), and that the PPC is responsible for subjective experience of confidence and vividness in retrieval of episodic memory (Ally, Simons, McKeever,

Peers & Budson, 2008). Clearly, more research into the role of the parietal cortex in memory function is needed.

1.4 Lateralization of memory

As mentioned, the human brain is composed of a left and right hemisphere. Each side specializes in the integration and analysis of different types of information and memory processing known as lateralization of function. Lateralization also involves the identification of the dominant hemisphere. Cerebral lateralization typically follows handedness with studies showing that 90% to 95% of adults are right-handed (Annett, 2002). A person with a typical right-handed preference will have a left-hemispheric language representation in approximately 95%-99% of patients (Borod, Carper, Naeser & Goodglass, 1985). Left-handed individuals have shown approximately 70%-80% left-hemispheric dominance for language utilizing Wada testing (Branch, Milner & Rasmussen, 1964). The Wada testing involved the unilateral injection of sodium amobarbitol into the internal carotid artery or femoral artery to "turn off" that hemisphere. The incidence of right-hemispheric dominance for language in this group has been more difficult to estimate. This is in part due to a misunderstanding that language laterality has to be either left or right and does not take in to account bilateral distribution according to Wada testing (Risse, Gates & Fangman, 1997).

The concept of lateralization is taken from studies of amnesic patients, lesion studies of animals and studies involving unilateral temporal lobectomy patients. In approximately 33% of left-handers, aphasic disorders are associated with right-sided lesions (Borod et al., 1985) and of these patients, 50% have bilateral language

representation (Blumstein, 1981). Studies have shown that the left hemisphere typically analyzes verbal information whereas the right hemisphere analyzes nonverbal information in most patients with left hemispheric dominance (Anderson, 2005). The dissociation of function for verbal and nonverbal memory has been shown in various studies (Smith & Milner, 1984; Frisk & Milner, 1990). Patients who have undergone unilateral temporal lobectomy for temporal lobe epilepsy (TLE) show lateralization of material-specific function. These patients typically exhibit a decline in verbal memory following surgery for the language-dominant hemisphere and a decline in topographical memory following non-dominant temporal lobectomy (Spiers et al., 2001).

Studies on nonverbal components of cognitive functioning have implicated hippocampal activity within the brain during spatial measurement tasks. Cohen (1992) studied children with complex partial epilepsy in the temporal lobe region and the research revealed that children with right TLE performed significantly worse than controls on visual/spatial memory testing. Specifically, the MTL, the perirhinal cortex and the anterior section of the hippocampus mediate visual discrimination and the processing of the spatial relationships between features that constitute an object or scene (Rosazza et al., 2009). The body and tail of the hippocampus were activated by objects, and only marginally by words, according to the study by Rosazza et al. (2009) indicating a specialization of function according to structure. Ploner et al, (2000) further examined the anatomical correlates of visual-spatial memory and found that patients with lesions of the parahippocampal cortex (PHC) and the perirhinal cortex (PRC) exhibited a delay-dependent inaccuracy on the contralateral side of the lesion, yet patients with PRC lesions showed no such inaccuracy. This shows that the PHC is critical for spatial memory.

Additionally, neuroimaging studies have suggested that brain lateralization also occurs dependent upon the temporal stage of memory processing (Kelley et al., 1998). Studies have shown greater left frontal lobe activity concerning a variety of tasks that are involved in long-term memory encoding and right frontal lobe activity during memory retrieval tasks (Tulving, Kapur, Craik, Markowitsch, & Houle, 1994; Nyberg, Cabeza & Tulving, 1996). Kelley et al. (1998) showed that the dorsal frontal cortex revealed left-activation for word encoding, bilateral activation for object encoding and right-activation for face encoding. For this study, left activation for word encoding is likely due to the verbal lateralization already discussed. Bilateral activation for object encoding could represent both a verbal and nonverbal component as shown by memory performance results. Unfamiliar faces would likely have activated the right dorsal frontal cortex as there were no verbal components available for encoding. They also found that the MTL activation was consistent with earlier studies of hemispheric dominance with left activation during word encoding and right activation during face encoding. Interestingly, Kelley et al. reported left MTL structure activation with both verbal and nonverbal materials. They suggest this may be due to the response of MTL structures to dual attributes for encoding.

There has been some criticism of Kelley et al. (1998) due to the use of a blocked design vs. an event-related design of memory encoding (Powell et al., 2005; Bonelli et al., 2010). They contend that an event-related design affords the opportunity to determine whether activity is due to encoding or to other cognitive processes. Event-related designs offer the ability to determine if activation of the anterior hippocampal structure while encoding occurs as this is critical when considering surgical intervention

for epilepsy, lesion location or other damage to the structure (Bonnelli et al., 2010). Powell et al. (2005) examined if there was an interaction between subsequent memory, material type and laterality to determine material-specific lateralization and functional segregation by utilizing an event-related design. This allowed for the subsequent memory effect to be analyzed within the MTL and the functional anatomy to be more precisely identified. They found that activation was left-lateralized for verbal encoding, bilateral for picture encoding and right-lateralized for face encoding. In addition, event-related analysis showed more anterior MTL activation meaning that localization of memory encoding was inconsistent in block designed studies due to the inability to measure subsequent memory formation.

1.5 Effects of alcohol on memory

Alcohol is one of the most common drugs used across the world today and most know of the particular effects produced when consumed (Soderlund, Grady, Easdon, & Tulving, 2007). Alcohol is a non-ionized, lipid-soluble compound that is quickly absorbed in the stomach, small intestine and colon and is readily distributed throughout the body (Zeigler et al., 2005). Alcohol is mainly oxidized by alcohol dehydrogenase to acetaldehyde and a small portion by cytochrome P450 isoform at approximately 98% of the ingested dose (Zeigler et al., 2005). It readily crosses the blood-brain barrier creating intoxication, which is commonly accepted as .05 to .08 percent blood alcohol content (BAC), and can impair various cognitive functions. Alcohol abuse includes behaviors that continually enforce intoxication.

Alcohol dependence, typically accepted as alcoholism, includes the mood and behaviors exhibited with chronic heavy alcohol consumption. There is also a difference between acute consumption of alcohol, actively ingesting alcohol, chronic exposure to alcohol, and active consumption over long periods, and effects are dose dependent (Zeigler et al., 2005). Although alcohol consumption affects cognitive functioning on many levels, one key area of interest concerning the effects of alcohol involves memory function. Recent research has shown that certain regions of the brain and memory types are selectively vulnerable to the effects of alcohol consumption (Lee, Roh & Kim et al., 2009). Understanding brain damage models and how alcohol affects memory types is key to understanding the outcomes of alcohol consumption on memory.

There are several models hypothesized to explain the brain damage that results from chronic alcohol consumption. Characteristics of individual alcoholics and vulnerable brain systems are two possible categories (Oscar-Berman & Marinkovic, 2003). Evaluation of individual characteristics utilizes special testing. The premature aging hypothesis posits that alcoholism accelerates chronological aging at onset of drinking (Oscar-Berman & Marinkovic, 2003), however, an alternative to this hypothesis is that patients over 50 show more vulnerability based on cumulative effects and this premature aging is only present in later life. Oscar-Berman (2000) proposes that there is a disproportionate effect on the brain in older adults. The damaging effects of alcohol on the brain implicate gender because alcohol affects women differently than men due to metabolic mechanisms although evidence is lacking as to the long-term differences in those effects (Oscar-Berman, 2000). A family history of chronic use of alcohol is another hypothesis for damage to the brain due to electrical activity differences (Porjesz &

Begleiter, 1998). Vitamin deficiencies may contribute to damage, specifically thiamine (vitamin B_1) (Oscar-Berman, 2000).

Models based on vulnerable brain systems highlight the cortex (grey matter) and nerve fibers for connection of cortical regions (white matter) with deep structures within the brain, or subcortical regions. Areas showing vulnerability include the cerebral cortex, the limbic system, the thalamus, the hypothalamus and the basal forebrain (Oscar-Berman, 2000) as well as the cerebellum (Sullivan, 2000). One model concerns brain atrophy resulting from the neurotoxic effects of alcohol (Lishman, 1990) resulting in permanent cognitive deficits and a mild or transient amnesic disorder with short-term memory loss (Oscar-Berman & Marinkovic, 2003). Another model includes frontal lobe vulnerability to damage that increases as alcoholics age (Sullivan, 2000) and changes in blood flow or metabolism in this area according to neuroimaging studies (Adams, et al., 1998). Additionally, the right hemisphere is implicated as being especially vulnerable to the effects of alcohol compared to the left (Oscar-Berman & Marinkovic, 2003). Finally, neuronal communication disturbance is another model implicated as a cause for cognitive deficits resulting from alcohol consumption. Neurotransmitter activity is altered with alcoholism causing neurons to either become excitable or be inhibited (Weiss and Porrino, 2002) and is dose dependent.

Research has shown that alcohol affects episodic memory at the encoding level more so than the retrieval level for verbal and nonverbal information (Soderlund et al., 2007). There is also evidence that the right hemisphere may be more vulnerable to the effects of alcohol. Using fMRI technology, Soderlund et al. demonstrated specific areas are activated in relation to the acute effects of alcohol including: a) the inferior frontal

gyrus region (for verbal and nonverbal tasks), b) the right middle frontal (for objects) and inferior frontal gyri (for face-names), and c) the parahippocampal (for objects) and fusiform gyri (for faces), all of which impacted the performance of specific types of explicit memory tasks by intoxicated individuals. Additionally, in alcoholics (as defined by the Diagnostic and Statistical Manual of Mental Disorders IV Text Revision (DSM-IV-TR)), alterations in grey matter microstructure were noted in the frontal, temporal, parahippocampal and cerebellum regions in detoxified alcoholics (Chanraud et al., 2009). This shows that explicit memory is specifically altered in detoxified alcoholics as well, although at the retrieval stage as these structures mediate explicit memory. Detoxified alcoholics are defined as those who were diagnosed as alcohol dependent per the DSM-IV-TR and have not ingested alcohol in fewer than three weeks at assessment (Chanraud et al., 2009).

White matter is also implicated in memory and atrophy causes specific memory deficits and is usually found on autopsy or specialized scans of alcoholics (Jernigan, Schafer, Butters, & Cermak, 1991). This is critical as the white matter forms connections between various areas of the brain allowing for communication between structures. Recent research has shown that chronic and heavy drinking leads to changes in the corpus callosum, especially in male alcoholics, and on the frontal, temporal, ventricular and corpus callosum white matter of women (Ruiz, Oscar-Berman, Sawyer, Valmas, Urban & Harris, 2012). This implicates white matter changes may vary by gender in alcoholics.

Response to alcohol also has to be considered when determining the effects of alcohol consumption on working memory. As mentioned, working memory involves holding information in memory while performing complex tasks simultaneously. When

performing a working memory task in one study, those who were considered low-level responders (i.e. less sensitive to the effects of alcohol) showed the same performance with placebo and moderate doses of alcohol, indicating that a higher degree of mental resources are not needed to maintain task performance (Trim et al., 2010). This means that the capacity to retain information in working memory is not affected with moderate doses of alcohol for these subjects. In another study, low-level responders did not differ from high-level responders concerning response latency or errors when assessing visual working memory, even when an increased load was placed on working memory, despite the consumption of alcohol (Paulus, Talpert, Pulido, & Schuckit, 2006). However, low-level responders have increased activation in the cortex under placebo conditions as working load increased while completing a visual working memory task. This means that lower BAC is not necessarily related to working memory task performance in this group, but brain activation and memory may be attenuated by alcohol consumption for low-level responders and causes additional resources to be used to perform a memory task. Alternately, another study indicated impairment of working memory is likely to occur when performing working memory tasks that require rehearsal of auditory and visual sequences while consuming moderate doses of alcohol (Saults, Cowan, Sher, & Moreno, 2007).

Cerebellar and prefrontal lobe functions are particularly vulnerable to the effects of alcohol consumption. Chronic alcohol exposure results in structural damage to both areas as there are interconnections via the thalamus that create a circuit between the two structures (Zahr et al., 2010). Specifically, the executive network is implicated in working memory, set shifting, planning and inhibition of behavior and from both a

volume and functional perspective, has been shown to be the best predictors of performance on spatial working memory (Zahr et al., 2010). This would mean that a volume change or disruption in the network would result in a deficit in memory due to alcohol consumption although the effects would be dependent upon moderate versus chronic use or abuse. An fMRI study of the frontal lobe indicated differences in left frontal lobe activity between alcoholics and non-alcoholics while performing a verbal working memory task showing an increase in activity based on high versus low working memory load suggestive of a compromised frontocerebellar circuit in alcoholics (Desmond, Chen, De Rosa, Pryor, Pfefferbaum & Sullivan, 2003). Desmond et al. further contend a compromise in the frontal-superior cerebellar circuit in alcoholics and this circuit contributes to the articulatory control process of verbal working memory causing compensatory brain activation in the left frontal and right superior cerebellum. Hypothetically, this control process updates the phonological store via rehearsal, which maintains the memory trace of the material to be stored and this results in the cerebellum supplementing the function of the neocortically based phonological loop for efficiency.

Volume studies have also been completed concerning the striatum and forebrain nuclei volumes and the effects of chronic alcohol exposure and working memory effects. Verbal working memory was assessed using neuropsychological testing which showed that the caudate and putamen are significantly reduced in volume in alcoholics. The nucleus accumbens was slightly reduced although not significant (Sullivan, Deshmukh, De Rosa, Rosenbloom, & Pfefferbaum, 2005). The striatum is important in dopamine-mediated functions and implicit memory regarding procedural skills, habits and

reductions in volume affect memory performance although typically implicit memory is not as affected by alcohol.

By far the structure most implicated in the effects of alcohol on memory is the hippocampus. The hippocampus is often thought of as the "relay station" of memory via the hippocampal pyramidal cells such as CA1 and is significantly involved in the formation of memories (White, 2003). One hypothesis is that excessive alcohol use results in increased N-methyl-D-aspartate (NMDA) receptor activity during alcohol withdrawal and inhibition of the receptors causes up-regulation (Zeigler et al., 2005). This in turn causes an increased amount of calcium channels and withdrawal of alcohol causes an influx of calcium into neurons and cell death can result (Zeigler et al., 2005). There are also implications that long-term potentiation is involved via NMDA receptor activity causing the detrimental effects of alcohol consumption in memory formation and functioning (White, 2003). The cortex sends information to the hippocampus and the hippocampus integrates the new information, by forming new autobiographical memories for instance, and then sends the information back out to the cortex (White, 2003). Hippocampal function is especially related to visual-spatial memory and consolidation of memory (Bartels et al., 2007). Studies of the effects of alcohol consumption on memory correlate with minor decreases in hippocampal volume (Laasko et al., 2000) all the way to significant loss of hippocampal volume (Beresford et al., 2006) in chronic heavy drinkers. It has long been accepted that alcohol impairs the ability to form new memories via disruption of hippocampal functioning. This was determined via studies that showed hippocampal lesions and alcohol intoxication produced the same memory deficits (White, 2003).

In addition to understanding the types of memory, the structures related to specific types of memory, and the effects alcohol produces on them, the effects of alcohol on memory also depend upon the age and brain development of the subject at the time of the exposure as well as the length of exposure. Prenatal exposure to alcohol can cause Fetal Alcohol Syndrome (FAS) and research has confirmed that this has teratogenic effects on the development of the hippocampus in animal models. FAS results in verbal and nonverbal memory deficits, as well as working memory deficits, and are due to the developmental alterations of the brain that have a continuous effect (Mattson, Crocker, & Nguyen, 2011). Verbal learning recall is particularly affected in both free recall tasks and recognition tasks (Mattson et al., 2011). Nonverbal learning is also affected in delayed recall tasks and visual-spatial memory results are mixed (Mattson et al., 2011).

Young adults and college-aged individuals (aged 13-29) often engage in high-risk behavior and use alcohol excessively and magnetic resonance imaging shows that alcohol use and abuse causes detrimental effects to memory and brain structures (Zeigler et al., 2005). This can lead to neurodegeneration that affects semantic and figural memory due to hippocampal damage (Zeigler et al., 2005) and prefrontal damage (Crego et al., 2010). This may affect the strategies adolescents employ when completing memory tasks (Schweinsburg, Schweinsburg, Nagel, Eyler, & Tapert, 2010). The detrimental effects on the development of the adolescent brain are well documented and have long-lasting impacts on memory due to the nature of the time point when alcohol is consumed.

Interestingly, alcohol consumption in middle aged subjects (aged 39-53) showed differences in cognitive impact in a follow-up study dependent upon amount of consumption - with no use and heavy use showing a risk of dementia in old age but

moderate drinkers showing no increased risk (Anttila et al., 2004). Anttila and colleagues found that the risk of alcohol related dementia later in life was modified by the apolipoprotein e4 allele and heavy alcohol consumption resulted in greater effects on memory despite the overall length of exposure. Although alcohol-associated dementia (AAD) and Wernicke-Korsakoff syndrome (WKS) are often present in elderly patients who are classified as heavy and chronic drinkers, even elderly subjects who drank moderately over time without ADD and WKS showed memory deficits including working memory (Vetreno, Hall, & Savage, 2011). This was due to cortical loss and hippocampal damage and a reduction in white matter due to the nature of the length of exposure to alcohol (Vetreno et al., 2011). In WKS, dysfunctions of neurons in the cholinergic system are implicated in memory impairment, however, cholinergic activity did not seem to correspond with the severity of memory disturbances contrary to other studies (Nardone et al., 2010). Thiamine deficiency and nutrition are also implicated in the formation of WKS and studies show the effects of age are directly involved in the nature of memory deficits (Moscovitch, 2005a).

Other factors that influence the effects of alcohol consumption on memory include the amount and frequency of intake. After only two alcoholic drinks, commonly called moderate intake, many people find they may have some difficulty in typical tasks requiring balance, speech, reaction time and memory. A BAC of only 50-100 mg/DL typically produces intoxication and can affect memory (Zeigler et al., 2005). Additionally, two major factors that impact memory formation are binge drinking (BD) (i.e. consuming large quantities of alcohol in a relatively short period of time and then repeating the process after a period of abstinence) and blackout drinking (i.e. consuming

large amounts of alcohol in a short period of time leading to acute intoxication with subsequent memory loss for a particular period of time). There are acute effects on memory due to alcohol consumption as well as sustained effects after repeated binge and blackout drinking episodes (White, 2003).

Typically, binge drinking involves adolescent and college-aged students due to social, emotional, and decision-making skills (Zeigler et al., 2005). Following intoxication, research shows that subjects perform poorly on tasks that require retention and manipulation of information stored in verbal working memory and the ability to monitor self-generated responses in working memory (Prada et al., 2012). Prada and colleagues found that this age group is particularly vulnerable to the effects of alcohol on brain structures die to brain maturation. Students also had difficulty in performing tasks involving executive functions that are part of working memory by creating more perseverations when giving self-generated responses due to impairments in cognitive control (Prada et al., 2012). Binge drinking can lead to blackouts as well. There is evidence that alcohol consumption affects female college students more than males typically due to physiological factors such as body weight, fat percentages and enzyme levels and there are resultant increased memory deficits (White, 2003). Blackouts have been produced with BAC levels of .14 to .20 (White, 2003). Blackout drinking, which results from a rapid increase in BAC, affects the encoding of memories primarily, but there is evidence that there are retrieval difficulties as well (Lee et al., 2009). There is also the possibility that once a person has a blackout that causes memory impairment, he/she is more likely to experience another blackout episode (White, 2003). Blackouts involve episodic memory (i.e. the time, place and related circumstances surrounding an

event) (Lee et al., 2009). Bingeing and blackout drinking are major factors in the effects of alcohol on memory formation including encoding and retrieval and vary in their implications on neurocognitive function.

1.6 Effects of alcohol abstinence on memory

Considering the detrimental effects on memory related to alcohol consumption, what happens once a person abstains from alcohol after chronic use or abuse? This depends upon the length of abstinence, the duration of use, and the age at onset and cessation of use, as well as comorbid factors such as intelligence quotient (IQ), general health and education level. This is in part due to the amount of atrophy and alcohol-related effects on cognition that are attenuated over time and the extent of deficits may primarily depend upon nutrition and medical comorbidities as well (Zinn, Stein, & Swartzwelder, 2004).

Some recovery of function has been shown to occur. General memory improved after four months of abstinence, alcoholics displayed normal episodic memory and executive function after a six-month period of abstinence, and hippocampal function was recovered at a two year follow-up for a group of alcoholics (Rosenbloom et al., 2007; Pitel et al., 2009; Bartels et al., 2007). Those abstinent between approximately 4 and 6 months showed better performance on memory tasks than those who had relapsed (Rosenbloom et al., 2007) and episodic memory returned to normal (Pitel et al., 2009). Mann, Gunther, Stetter & Ackerman (1999) conducted a neuropsychological study of cognitive deficits in abstinent alcoholics to assess learning effects and the amount of cognitive recovery and found that impairment was evident for verbal and non-verbal

tasks. However, differences for all neuropsychological parameters reached non-significant levels within several weeks except for verbal short-term memory.

In contrast, some research has shown the opposite. Subjects in early abstinence (7-16 days) have shown impairment in memory discrimination tasks (Zinn et al., 2004), less effective use of organizational strategies in visual memory tasks (Daig et al., 2010), and impairment in working memory (Loeber et al., 2009). Other studies have shown verbal memory deficits persist (Davies et al., 2005) and abstinence of 5 or more years did not show improvements on paired-associate tests measuring long-term memory (Brandt, Butters, Ryan, & Bayog, 1983). Davies et al. (2005) found persistent frontal lobe dysfunction following a neuropsychological assessment of healthy abstinent alcoholics. There are also severe deficits following chronic heavy alcohol abuse including Wernicke's encephalopathy and Korsakoff's syndrome (Davies et al., 2005).

Frontal lobe functioning shows the earliest and most widespread atrophy in alcoholics (Cala & Mastaglia, 1981) and this is evident in both imaging and autopsy of alcoholics. This impairment in frontal lobe functioning is also shown to persist despite abstinence (Davies et al., 2005). In addition, slow, but some recovery, of hippocampal function does occur if abstinence from alcohol is strictly maintained (Bartels et al., 2007). Additional brain regions involved following abstinence include the cerebellum and limbic system (Oscar-Berman & Marinkovic, 2003). Understanding the anatomical and functional changes likely in abstinence following alcoholism can lead to a better neuropsychological evaluation and interpretation of results.

Impairment in performance on memory tasks increases as the difficulty associated with the tasks increase in abstinent alcoholics (Davies et al., 2005). In addition, studies

have reported that 50-75% of abstinent alcoholics experience cognitive and memory dysfunction (Vetreno et al., 2011). Understanding the implications of memory dysfunction involved in early abstinence has a direct impact on the treatment of individuals recovering from alcoholism. Services to remediate these memory deficits may be valuable to individuals new to abstinence. Sustaining abstinence from alcohol seems to be the key to any chance of recovery from memory dysfunction for most alcoholics and strategies to live with the deficits are important components in the treatment and recovery processes.

The long-term detrimental effects of chronic heavy alcohol consumption are likely to be far-reaching into adulthood and the geriatric years. Amazing advancements in the field of neuroimaging have allowed researchers to study anatomical, functional and biochemical changes in the brain following chronic alcohol use into abstinence. These include fMRI enhanced with tracking blood oxygenation level-dependent or BOLD that allows tracking of blood and oxygenation of specific regions. Electroencephalography (EEG), event-related brain potentials (ERP) and magnetoencephalography (MEG) are used to track changes in the brain following abstinence from alcohol. These methods have shown that it is possible for metabolism within the cerebral cortex to improve following only a month of abstinence, especially in the frontal lobes, and with continued abstinence loss of brain tissue can be reversed (Sullivan, 2000).

1.7 Assessment of Memory

Since memory is a vital component to functioning, the ability to conduct an accurate memory assessment is critical, especially in clinical populations. Any memory

assessment should include three main procedures: 1) immediate recall trials along with a delay trial (to show both temporary and longer-term learning), 2) interference during the delay (to prevent continuous rehearsal), and 3) recognition trial (to assess if subpar performances are due to learning impairment or retrieval problems). In addition, the lateralization of processing of verbal and nonverbal memory by the brain necessitates neuropsychological assessments that target each construct. There has been a rapid evolution in the field of neuropsychological assessment and this expansion needs to consider modality differences of the major aspects of the memory system.

There are many neuropsychological verbal memory tests available, however, a limited number have reliable norms based upon methodical standardization (Lezak et al., 2004). Most neuropsychological verbal memory tests assess level of recall for explicit material, forgetting rates, vulnerability to proactive interference, encoding versus retrieval problems, intrusion rates and recognition discrimination (Delis, Massman, Butters, & Salmon, 1991). Modern neuropsychological memory assessment is able to distinguish between different memory disorders. Verbal memory assessments are useful in many clinical populations including traumatic brain injury, epilepsy, Alzheimer's disease and chronic alcoholism (Delis et al., 1991). The ability of neuropsychological assessments to measure verbal memory in these populations is critical to the successful evaluation and possible rehabilitation of memory function.

The most commonly used verbal memory assessments include the Rey Auditory Verbal Learning Test (RAVLT) and the California Verbal Learning Test -II (CVLT-II). Both utilize a multiple trial list-learning task. The assessments also allow for the measurement of the manner in which information is both learned and retrieved. In

addition, forced-choice recognition tasks, interference, immediate and delayed recall are assessed in each test as well as evaluation of learning over a five-trial method. Studies utilizing the CVLT-II in clinical populations include focal frontal lesions (Baldo, Delis, Kramer & Shimamura, 2002) and self-reported depression and anxiety (O'Jile, Schrimsher & O'Bryant, 2005). Clinical studies utilizing the RAVLT are extensive including left temporal lobe dysfunction (Majdan, Sziklas, & Jones-Gotman, 1996), WKS (Shimamura, Salmon, Squire & Butters, 1987), and laterality of brain damage (Kilpatrick, Murrie, Cook, Andrewes, Desmond & Hopper, 1997). Age, gender, IQ and education all correlate with performance on these two assessments.

Assessment of nonverbal memory has shown mixed results across studies. One theory as to the conflicting results is postulated to be the manner in which nonverbal memory is assessed. The results may be due to the type of tasks and assessments utilized to study nonverbal memory, as many have used single-trial tasks. This does not allow for multiple presentations of materials and the impact of repeated exposure and learning is not assessed. Questions as to the ability to use sub-vocal mediation questioning whether such tasks are truly nonverbal (Lee, Yip, & Jones-Gotman, 2002) have also been raised. In addition, factors such as attention and executive functions can affect constructional abilities and the outcome of the assessments (Wisniewski, Wendling, Manning & Steinhoff, 2012). The validity and reliability, as well as the specificity and sensitivity, of neuropsychological assessments are an important aspect and outcomes of testing should reflect what is purported to have been evaluated.

Currently, the most commonly used neuropsychological assessments of nonverbal memory are the Rey Osterreith Complex Figure Test (ROCF) and the Taylor Complex

Figure (TCF). These tests allow for some verbal mediation of nonverbal memory by using language to mediate the tasks. They also have a limited number of trials, one being the initial drawing followed by an immediate reconstruction and then a delayed reconstruction. This subtle aspect of the testing procedure, which does not allow for learning to occur via repeated trials, may account for the reason the results are variable when assessing nonverbal memory. Furthermore, another problem ensued from the complex figure drawings are the nature of the stimuli, number of learning trials, stimulus presentation time and the format for testing the memory stimuli (Foster, Drago & Harrison, 2009). A good measure of visual-spatial learning should correspond to that of verbal learning measures in the number of stimuli, learning trials and format for assessing memory. In spite of these limitations, as well as the difficulty in scoring these measures, neuropsychologists have continued to use them.

1.8 Hypotheses

The goals of the study were to (1) Assess for differences in verbal and nonverbal memory and learning between abstinent alcoholics and controls, namely that abstinent alcoholics would exhibit impaired nonverbal memory and intact verbal memory and show a learning impairment on verbal and nonverbal measures when compared to normals, (2) Compare the learning curves between the new nonverbal measure, the Poreh Nonverbal Memory Test, and the Rey Auditory Verbal Learning Test to determine if they exhibit the same logarithmic learning curve and (3) Assess whether the new measure possesses construct validity and differentially correlates with existing verbal and nonverbal memory tests in a clinical population. Namely, it will correlate highly with the

Rey Complex figure, but not as highly with the indices of the Rey Auditory Verbal Learning Test. Given that the Rey Complex Figure involves planning and organizational skills as well as verbal mediation, the correlation with this measure is expected to be significant, but not extremely high.

CHAPTER II

METHODS

2.1 Participants

The sample consisted of sixty-seven volunteers (age range 22-64 years) from the greater Cleveland area. Thirty-two were classified as controls with no history of alcohol abuse. Thirty-five were self-reported abstinent alcoholics. All alcoholics met criteria for Alcohol Dependence with physiological dependence with either early or sustained full remission per the Diagnostic and Statistical Manual of Mental Disorders-IV-Text Revision (DSM-IV-TR). The study was approved by the Cleveland State University Institutional Review Board. All subjects provided their informed consent for participation in the study following an explanation of the study protocol.

2.1.1 Control subjects

Control subjects (N = 32) were recruited via university students and word of mouth volunteers. It included healthy men (N = 19) and women (N = 13) with no history of alcohol abuse, psychiatric or neurological disorders, and subjects were not currently

taking any prescription medications known for cognitive alterations. Age range was 22 – 61 years (M=40.31, SD=13.583) and education range was 12 – 19 years (M=15.38, SD=1.963). The sample was 93.8% Caucasian and 6.2% African American. 12.5% were left-handed and 87.5% were right-handed.

2.1.2 Abstinent Alcoholics

The abstinent alcoholics (N = 35) were recruited from a newspaper ad in the metropolitan Cleveland area and all were associated with Alcoholics Anonymous. It included men (N = 20) and women (N = 15) with self-reported history of alcohol dependence per the DSM-IV-TR. The range of dependence was 1 – 32 years (M=11.429, SD=8.049) and the range of abstinence was 0.5 – 35 years (M=12.568, SD=10.669) both with a positive skew. The subjects were not currently taking any psychotropic medications or being treated for comorbid psychiatric disorders. Age range was 23 – 64 years (M=44.20, SD=12.216) and education range was 11-20 years (M=13.66, SD=2.057). The sample was 97% Caucasian and 3% African-American. 91.4% were right-handed and 8.6% were left-handed.

2.2 Measures

Rey Auditory Verbal Learning Test (RAVLT)

The Rey Auditory Verbal Learning Test (RAVLT) was designed in the early 1900's and has gone through multiple iterations since that time. The test consists of 15 nouns that are read aloud for five consecutive trials. Each trial is followed by a free recall test. An interference list of 15 words is then presented following the fifth trial that

is followed by a free recall test of the interference list. Immediately after that test, the subject is asked to recall the first list that introduces a delayed recall paradigm. After 20 minutes, the subject is asked to recall the first list again. Finally, a list of words, including items from both lists, is read to the subject for identification of words from the first list only. The RAVLT provides information about acquisition, learning rate, susceptibility to proactive and retrospective interference, and retention/forgetting. It has been shown to be sensitive to laterality of brain damage (Kilpatrick, et al., 1997). The sum of the words recalled in each trial determines performance. For this study, learning was measured by the change in number of words learned across the five trials.

Rey Osterrieth Complex Figure Test

The Rey-Osterrieth Complex Figure (ROCF) test was designed in 1941 by Rey and then was normed in 1944 by Osterrieth (Gagnon, Awad, Mertens, and Messier, 2003) and is now commonly used to assess visual memory and perceptual organization in adults who experienced brain damage (Hubley & Tremblay, 2002). The test is administered with a copy trial in which the figure is presented without cuing the subject of the need to recall the figure. The figure is then removed from sight and the subject may be asked to instantaneously draw the figure for an immediate recall trial, and/or be asked to draw the figure after a delay, called a delayed recall trial. After a 30-minute delay, the subject is asked to draw the figure from memory once again. Because the test does not have multiple trials, it is not a good measure of learning. Scores are assessed on the copy, 3-minute and 30-minute and are calculated based on the number of elements of the figure that are drawn in each phase for up to a total score of 36 points. When assessing right

temporal activity and visual memory, it is important to measure the hippocampal activity only and not the circuits between the temporal lobe and the pre-frontal cortex which introduces the element of planning and organization of visual stimuli. A comparison between the PNMT and the ROCF will allow for a correlation to be drawn concerning nonverbal memory with more specificity of localized function to be identified by the PNMT task.

The Poreh Nonverbal Memory Test

The Poreh Nonverbal Memory Test (PNMT), designed by Dr. Amir Poreh, is a new neuropsychological assessment that includes repeated trials to measure nonverbal spatial memory to assess learning. It was recently validated in a normal population and allowed for learning curves to be evaluated (Kociuba, 2011). The unique aspect of the test is that it is devoid of verbal cues and mediation for task completion. During assessment, the subject will complete nine configurations over five trials. On each trial, subjects will be asked to use the computer mouse to click white boxes displayed on the screen randomly until a box turns red indicating the correct box has been located. The subject may then review the placement of the box for ten seconds in order to commit it to memory. The next screen then becomes available and the subject repeats the process with a different configuration of boxes for nine total configurations. The nine configurations are repeated for five trials each. Scores are obtained by summing the number of clicks necessary to find the target. Learning is assessed by calculating the difference in the number of clicks over the five trials, which should decrease for each subsequent trial. The ability to review both repeated trial and limited trial assessments will provide additional

information concerning how nonverbal memory is mediated by the temporal lobes, particularly the hippocampi, and the learning curve that is involved in the process. In addition, the complexity of the configurations will also provide information concerning the usefulness of the assessment in clinical populations such as Alzheimer's, dementia, and epilepsy. The nine configurations alternate between simple, or symmetrical and more easily processed designs, and complex, or asymmetrical, designs.

2.3 Procedure

All participants were administered a collection of neuropsychological tests which consisted of the ROCF, the RAVLT and the PNMT. All neuropsychological assessments were administered by the principal investigator or trained research assistants. Standardized administration was ensured via training and rote use of printed administration instructions. The ROCF was administered first, consisting of the copy and then the three-minute delay trial. Participants then completed either the first five trials of the RAVLT including the interference trial and the immediate recall trial and then the first five trials of the PNMT or vice versa. Subsequently, the 30-minute delays for the ROCF, RAVLT, and the PNMT were given in the indicated order.

2.4 Data Analysis

Independent t-tests were utilized for between-group differences for the PNMT, ROCF and the RAVLT for verbal and nonverbal memory measures. The validity of the PNMT was examined through several different analyses. Item difficulty on the PNMT was assessed utilizing a multidimensional scaling analysis that also provided proposed

dimensions for performance on the assessment. Statistical analyses were comprised of comparing the validity and reliability coefficients to the well established non-verbal test of memory, ROCF for both groups. The correlation between the verbal and nonverbal measures were recorded and a logarithmic learning curve for the RAVLT and the PNMT were compared by group. A planned comparison was conducted to determine if there was a significant difference in learning between the control and experimental groups. Total learning for the PNMT and RAVLT were also examined and compared. Correlational analyses were conducted to determine the effects of length of alcohol dependence and abstinence on scores while controlling for education and age. A regression analysis was run to determine the effects of the length of alcohol dependence and abstinence on performance on verbal and nonverbal measures.

CHAPTER III

RESULTS

3.1 Results Between Groups for PNMT, RAVLT and the ROCF

Descriptive statistics for the five learning trials and delay trial on the PNMT were examined in order to determine the range of hit distribution for each trial by group. The mean, standard deviation, scenes and kurtosis were also examined. For each learning trial, the minimum and maximum column represents the range of items hit over the nine items presented. The average number of hits it took a subject to find the red square for all nine items on each trial is represented by the mean, and is the indicator of learning over the five total trials and memory for the delay trial. Abstinent alcoholics required more guesses and had a higher mean across trials 1-5 than did the control group, however, this difference did not reach significance; $t(65) = -1.826$, $p = 0.072$. Skewness and kurtosis were also examined in order to determine if each trial had a normal distribution of learning and recognition. Skewness and kurtosis for all five trails were not significant, showing each trial to be a good representation of learning and memory. Final descriptive results by group are shown in Tables 1 & 2.

Descriptive statistics for the five learning trials and delay trial on the RAVLT were examined in order to determine the range of hit distribution for each trial by group. The mean, standard deviation, skewness and kurtosis were also examined. For each learning trial, the minimum and maximum column represents the range of correctly recalled words from the fifteen words presented. The average number of correctly recalled words by a subject on each trial is represented by the mean, and is the indicator of learning over the five total trials and memory for the delay trial. Abstinent alcoholics correctly recalled fewer words and had a lower mean across trials 1-5 than did the control group, however, this difference did not reach significance; $t(65) = 1.854$, $p = 0.068$. Skewness and kurtosis were also examined in order to determine if each trial had a normal distribution of learning and recognition. Skewness and kurtosis for all five trails were not significant, showing each trial to be a good representation of learning and memory. A multiple regression analysis was conducted to determine if length of alcohol dependence or abstinence had an effect on recollection as measured by the RAVLT recognition trial. The results of the regression indicated that alcohol dependency was shown to predict a poorer performance on the recognition task in the experimental group ($R^2 = .174$, $F(1,34) = 6.939$, $p = 0.013$). Recognition is a measure of how much was learned despite retrieval efficiency. Final descriptive results by group are shown in Tables 3 & 4.

Descriptive statistics of the ROCF copy, 3-minute delay and 30-minute delay in order to determine the hit range for each task by group. The mean, standard deviation, skewness and kurtosis were also examined. For each phase, the minimum and maximum column represents the range of accurately recalled details of the original drawing. The

average number of correctly recalled details by a subject on each trial is represented by the mean, and is the indicator of recall over the three tasks. Abstinent alcoholics correctly recalled fewer details and had a lower mean for the 3-minute and 30-minute delays. An independent sample t-test of the ROCF 3-minute delay revealed that the abstinent group performed significantly poorer on the task (M = 19.172, SD = 5.227) than the control group (M = 15.900, SD = 6.196); t(65) = 2.325, p = 0.023). An independent sample t-test of the ROCF 30-minute delay revealed that the abstinent group performed significantly poorer on the task (M = 18.750, SD = 5.673) than the control group (M = 15.671, SD = 5.851); t(65) = 2.183, p = 0.033). This indicates the abstinent alcoholics encountered more difficulty in performing this task than the controls. Performance between the 3-minute delay and the 30-minute delay were similar within groups with the 3-minute delay assessing recall and the 30-minute delay assessing retention. This measurement, however, has no learning component as there are not repeated learning trials and it consists of the copy task, the 3-minute recall task and the 30-minute recall task. Final descriptive results by group are shown in Tables 5 & 6.

Table 1

PNMT Learning Trials-Descriptive Statistics-Control Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
PNMT1	27	66	48.63	9.648	-.040	-.016
PNMT2	9	45	30.38	9.241	-.409	-.540
PNMT3	9	53	26.44	10.800	.446	-.241
PNMT4	9	60	24.63	11.065	1.254	2.350
PNMT5	9	40	20.03	7.240	.391	.427
PNMTD	10	41	22.28	8.161	.709	-.008

N=32

Table 2

PNMT Learning Trials-Descriptive Statistics-Experimental Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
PNMT1	27	62	47.14	9.191	-.513	-.329
PNMT2	16	53	33.09	8.756	.522	.140
PNMT3	11	57	31.46	9.472	.440	1.029
PNMT4	9	51	28.23	10.239	.212	-.064
PNMT5	9	51	25.34	9.628	.718	.615
PNMTD	9	49	25.00	9.289	.330	.079

N=35

Table 3

RAVLT Learning Trials-Descriptive Statistics-Control Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
AVLT1	4	12	6.94	1.865	.606	.456
AVLT2	7	14	10.22	2.090	.142	-.671
AVLT3	7	15	11.59	2.168	-.308	-.653
AVLT4	8	15	12.28	1.955	-.643	-.467
AVLT5	9	15	12.72	1.689	-.511	-.755
AVLTD	6	15	11.06	2.758	-.177	-1.265

N=32

Table 4

RAVLT Learning Trials-Descriptive Statistics-Experimental Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
AVLT1	2	10	6.40	1.735	-.019	.019
AVLT2	6	14	9.46	2.091	-.018	-.617
AVLT3	7	15	10.94	1.955	.060	-.517
AVLT4	6	15	11.29	2.204	-.456	-.283
AVLT5	7	15	11.91	2.106	-.823	.101
AVLTD	3	15	10.46	2.593	-1.150	1.562

N=35

Table 5

ROCF - Descriptive Statistics-Control Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
Copy	21.0	36.0	30.250	3.994	-.610	-.312
3-minute Delay	6.0	29.0	19.172	5.227	-.621	.673
30-min Delay	5.5	28.0	18.750	5.673	-.471	.155

N=32

Table 6

ROCF - Descriptive Statistics-Experimental Group

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
Copy	23.0	36.0	30.429	3.660	-.400	-.590
3-minute Delay	2.5	27.0	15.900	6.196	-.376	-.511
30-min Delay	4.5	27.0	15.671	5.851	-.212	-.700

N=35

3.2 Graphs of delay measures on the PNMT, RAVLT and ROCF

Histograms for the PNMT-Total Delay, the RAVLT Delay and that ROCF Delay were examined by group in order to determine the complexity of memory measurement for each test. The histogram for the PNMT for the control group (Figure 1) was positively skewed. The positive skew for this graph indicates that it is a good measure of nonverbal memory as normal subjects should perform fairly well on this test, with fewer people falling on the high range. The histogram for the PNMT for the abstinent alcoholics (Figure 2) is less positively skewed than the controls indicating abstinent alcoholics experienced more difficulty in completing the task. The difference between groups did

not reach significance indicating that although the experimental group experienced more difficulty, they performed comparably to the control group.

The histogram for the RAVLT for the control group (Figure 3) is slightly negatively skewed indicating the normal subjects performed fairly well on this test. The histogram for the RAVLT for the abstinent alcoholics (Figure 4) is negatively skewed indicating the subjects again had more difficulty in completing the task. The difference in skewness direction is a result of higher scores on the RAVLT indicating better recall memory, while scoring lower on the PNMT indicates better recall memory making them inversely related. The RAVLT has also been shown to be a good measure of verbal memory, and normals should perform highly on this task. Again, the difference between groups did not reach significance and the performance of the experimental group was comparable to that of the control group.

Lastly, the ROCF histogram for the control group (Figure 5) had a graph that was slightly negatively skewed. This visual representation shows that the task is more difficult than the PNMT or the RAVLT and leaves more room for error in assessing nonverbal memory. The histogram for the ROCF for the abstinent alcoholics (Figure 6) is also negatively skewed indicating the subjects experienced more difficulty in completing the task. This may be due to the complexity and requirements of the task, which includes complex and distinctive features that require planning and organizational abilities to reproduce. This supports the conclusion that this task is more difficult for abstinent alcoholics than the measurements provided by the PNMT for nonverbal memory.

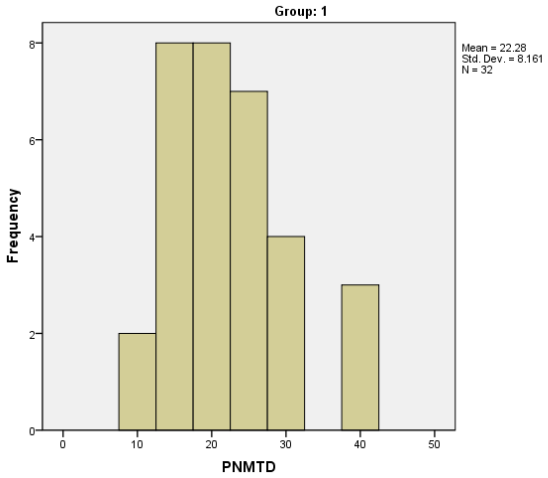

Figure 1: PNMT Delay Distribution of Scores – Control Group

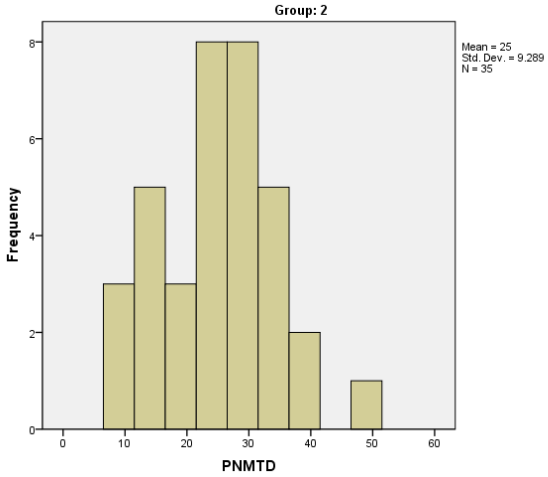

Figure 2: PNMT Delay Distribution of Scores – Experimental Group

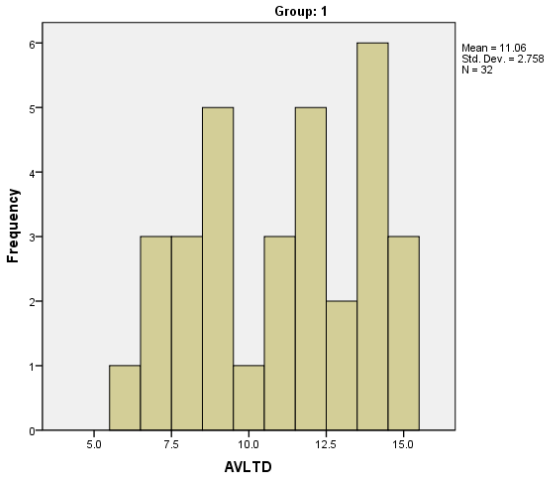

Figure 3: RAVLT Delay Distribution of Scores – Control Group

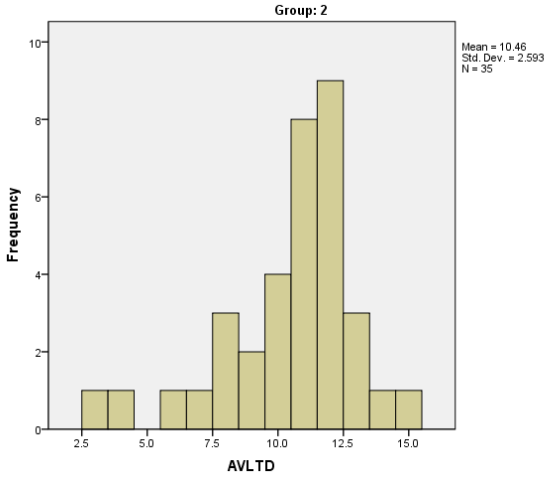

Figure 4: RAVLT Delay Distribution of Scores – Experimental Group

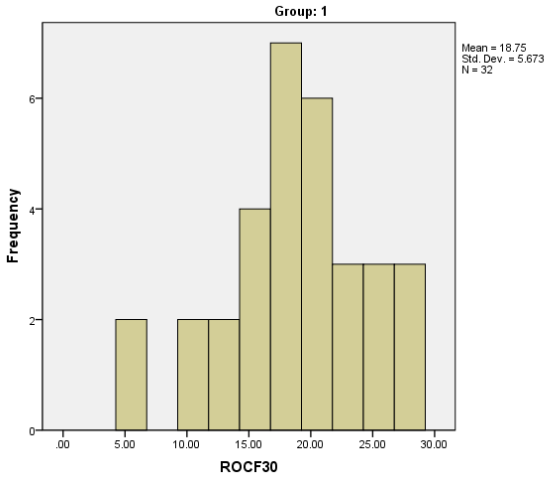

Figure 5: ROCF Delay Distribution of Scores – Control Group

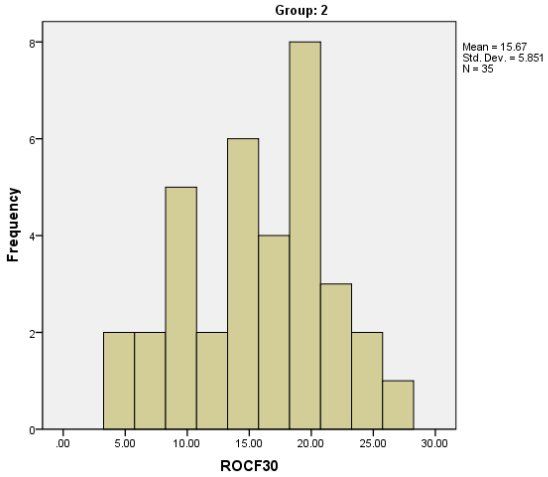

Figure 6: ROCF Delay Distribution of Scores – Experimental Group

3.3 Item Difficulty on the PNMT

A multidimensional scaling analysis was run to compare the simple and complex configurations by trial to determine the dimensions involved in completion of the assessment and examine the groupings by difficulty. Learning and memory were assessed

in the dimensions. Configurations categorized as simple (Figure 7) were 1, 3, 5, and 7. Configurations categorized as complex (Figure 8) were 2, 4, 6 and 8 and 9. The difficulty of these configurations depends on the premise that the design of each configuration for simple designs are symmetrical, or less novel, and more easily remembered. Complex designs, being asymmetrical, are not as easily recalled.

The control group (see Figure 9) shows clearer dimensions comprised of simple and complex configurations in memory performance. Dimension 1 may represent motivation and consistency of performance based upon observation of subjects while completing the task as the length of time to complete the task seemed to affect performance. Dimension 2 may represent the ease of recall. The experimental group dimensions (Figure 10) show a similar pattern except the ease of recall is more difficult across all but the PNMTS1 configuration and the results are not as tightly clustered meaning there is not a clear dimension. This may represent memory difficulties in abstinent alcoholics. PNMTS1 and PNMTC1 represent outliers. This is likely due to the primacy effect noted in neuropsychological assessments of memory as they are the first two configurations presented in each trial.

An independent sample t-test with complex total and simple total being the dependent variable shows that the abstinent group needed a higher number of clicks on the complex figures ($M = 101.971$, $SD = 20.155$) than the controls ($M = 90.281$, $SD = 19.967$); $t(65) = -2.382$, $p = 0.020$. The two groups did not differ with regards to the simple configurations; $t(68) = -0.852$, $p = 3.97$. Correlations by group to compare the relationship between the PNMT simple and complex configurations and the ROCF were completed. Final results are contained in Table 7. The results suggest that the

experimental group experienced more difficulty on the PNMT simple and complex configurations than did controls and this also correlated with their performance on the ROCF.

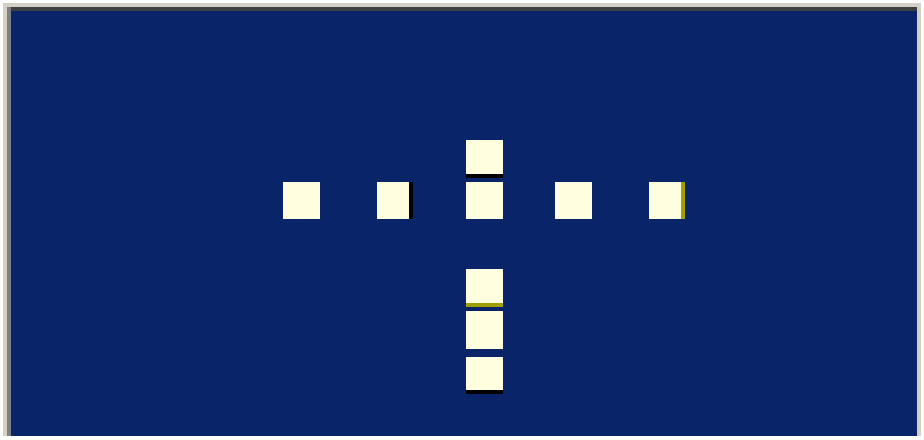

Figure 7: PNMT Simple Designs – Configuration 1

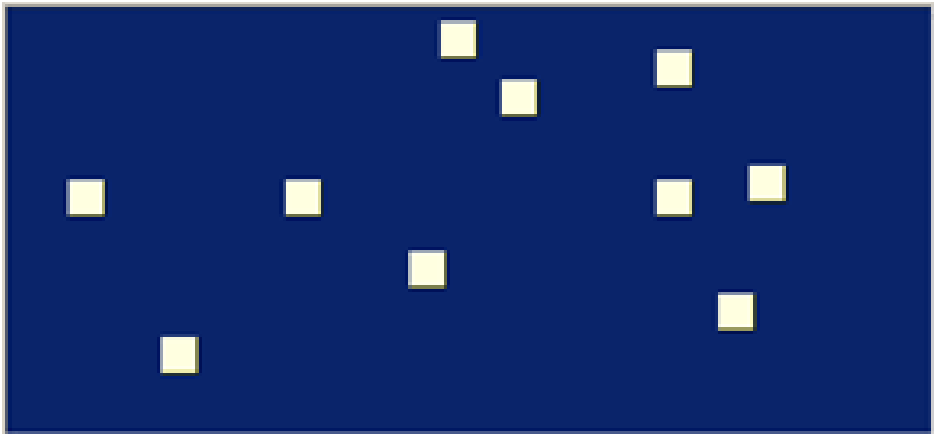

Figure 8: PNMT Complex Designs –Configuration 2

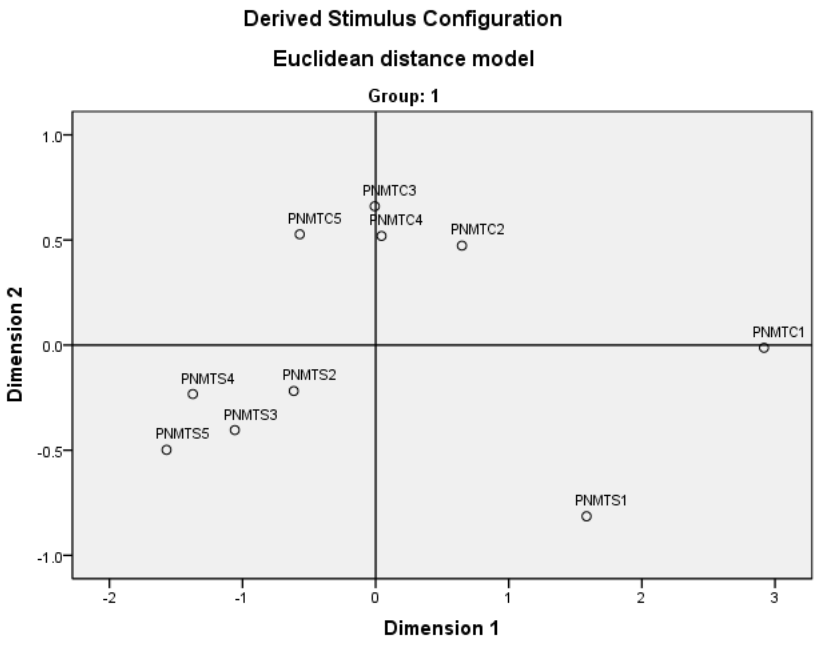

Figure 9: Control Group Dimensions – Simple and Complex

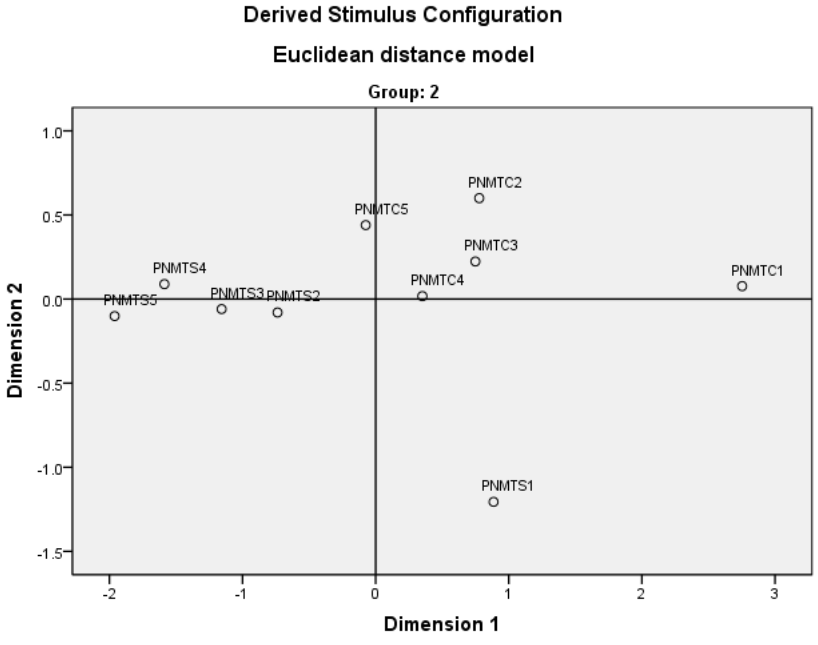

Figure 10: Experimental Group Dimensions – Simple and Complex

Table 7

PNMT and ROCF Correlations

Control Group	ROCF3	ROCF30
PNMT Complex Total	-0.328*	-0.377*
PNMT Simple Total	-.260	-0.391*
N=32		
Experimental Group		
PNMT Complex Total	-0.487**	-.540**
PNMT Simple Total	-0.459**	-0.427**
N=35		

* Correlation is significant at the 0.05 level (1-tailed)
** Correlation is significant at the 0.01 level (1-tailed)

3.4 Learning Curve Comparison

Total learning for the RAVLT and PNMT by groups across all five trials of each assessment was computed. Correlations were run to determine the learning relationship between the two tests. Computation of learning was completed across all five trails for both the RAVLT, by summing the total number of words learned, and the PNMT, by summing the number of hit-rates. The PNMT correlated significantly with the RAVLT at the .01 level, showing there to be a significant relationship of learning between the two tests (see Table 9). This relationship determines that total learning for the PNMT is similar to that of total learning for the RAVLT.

A logarithmic learning curve was additionally computed for the learning trials on the PNMT and the RAVLT for each group. Logarithmic learning is computed by 80% learning over each subsequent trial. The PNMT for the control group showed a log series with an R-squared of 0.9412 showing it to be a significant predictor of nonverbal learning

across five trials. The PNMT for the experimental group showed a log series with an R-squared of 0.9455 showing it to be a significant predictor of nonverbal learning across five trials for abstinent alcoholics. The abstinent alcoholic group required more clicks per configuration than did the control group indicating more difficulty in processing the memory task than controls. A logarithmic learning curve for the RAVLT for each group was also computed to determine learning over five trials. The RAVLT for the control group showed a log series with an R-squared of 0.9740 showing it to be a significant predictor of verbal learning across five trials. The RAVLT for the experimental group showed a log series with an R-squared value of 0.9702 showing it to be a significant predictor of verbal learning across five trials in abstinent alcoholics (see figures 11 and 12). The abstinent alcoholic group recalled less words per memory trial than did the control group indicating more difficulty in processing the memory task than controls. In addition, learning curves for the PNMT complex configurations were computed for both groups. The control group log series had an R-squared of 0.9379 and the experimental group log series had an R-squared of 0.9097. Again, indicating the complex configurations are shown to be significant predictors of nonverbal learning across the five trials (see figure 13).

A planned comparison by trial for complex configurations was completed to determine if there was a significant difference in performance between the control and experimental group. Independent t-tests were completed and no trials were significantly different at the 0.01 level (see Table 8). Overall, the abstinent alcoholic group required more clicks per complex configuration than did the control group indicating more difficulty in processing the memory task than controls.

Table 8

PNMT Complex Configuration Trials 1 - 5 Planned Comparison

	t	df	Sig. (1-tailed)	Mean Difference	Std. Error Difference
Trial 1	-.181	65	.857	-.249	1.379
Trial 2	-1.234	65	.222	-1.664	1.349
Trial 3	-2.128	65	.037	-3.313	1.557
Trial 4	-1.447	65	.153	-2.356	1.629
Trial 5	-2.619	65	.011	-4.107	1.568

Table 9

Correlations for Total Learning on PNMT and RAVLT

Control Group	RAVLT Five Trail Total
PNMT Five Trial Total N=32	-0.482**
Experimental Group	
PNMT Five Trial Total N=35	-0.622**

** Correlation is significant at the 0.01 level (1-tailed)

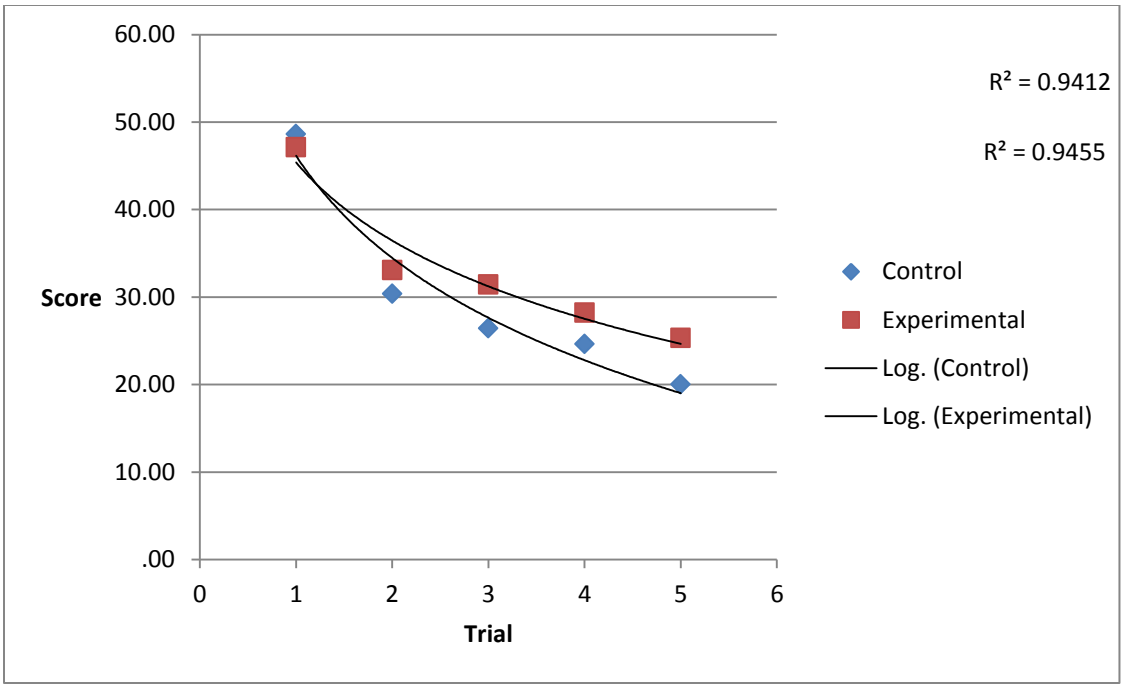

Figure 11: PNMT Learning Curve

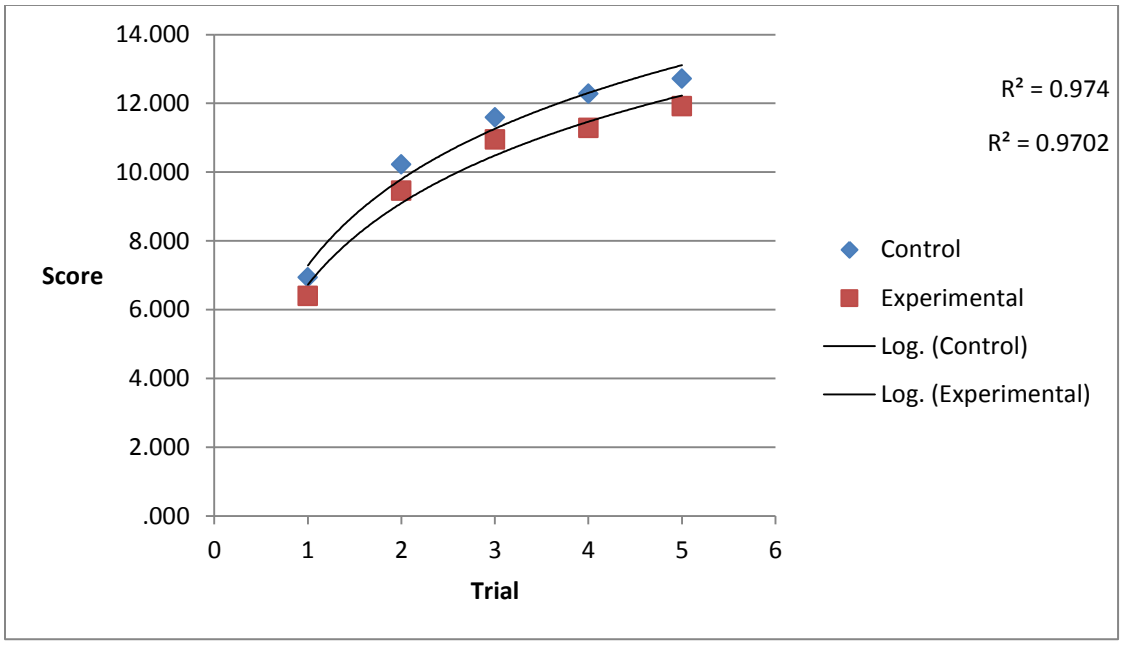

Figure 12: RAVLT Learning Curve

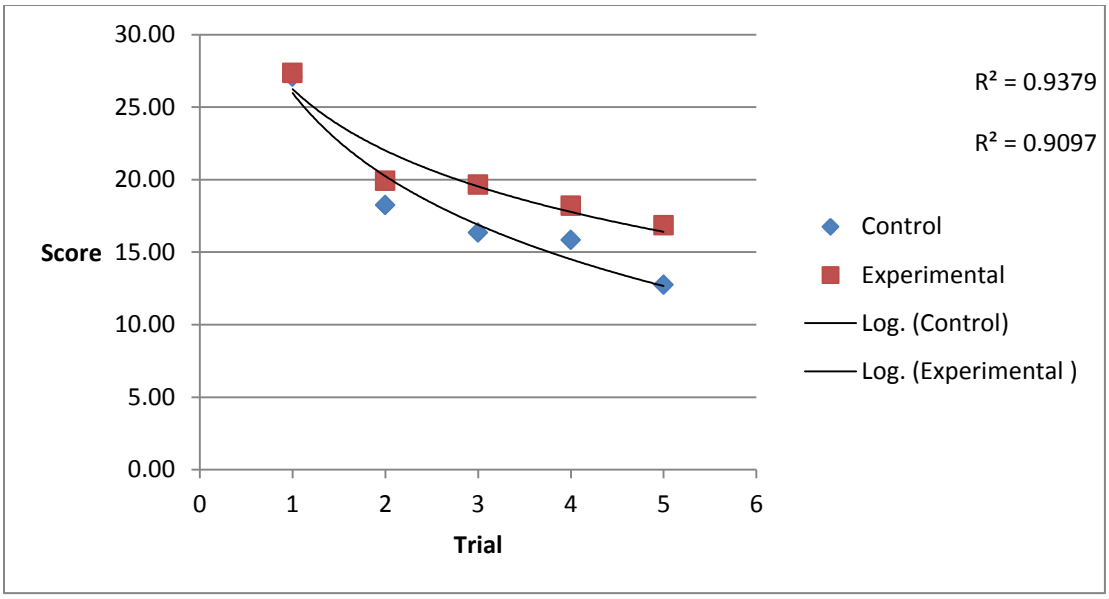

Figure 13: PNMT Learning Curve for Complex Configurations

3.5 Construct Validity of PNMT between groups

Construct validity of the PNMT was determined by running multiple correlations by group. As was previously shown, the PNMT delay correlated negatively with the ROCF three-minute and thirty-minute delays at the 0.05 level. This indicates that the PNMT is a good measure of nonverbal memory as it correlates with an existing measure of nonverbal memory. The greater the score on the ROCF, the more sufficient a subject's nonverbal memory is thought to be. The lower the score on the PNMT, the same holds true. Additionally, the PNMT delay correlates with the RAVLT Delay. This indicates the PNMT learning model is similar to the model indicated by the RAVLT outcomes and supports the learning curve results previously noted. Correlation results controlling for age and education on the PNMT, RAVLT and ROCF delays are contained in Table 10.

Table 10

Correlations for PNMT, ROCF, & RAVLT Delays Controlling for Age & Education

Control Group	RAVLTD	ROCF30
PNMT Simple Delay	-0.325*	-0.251
PNMT Complex Delay	-0.314*	-0.541**
PNMT Overall Delay	-0.361*	-0.462**
df = 28		
Experimental Group	**RAVLTD**	**ROCF30**
PNMT Simple Delay	-0.477**	-0.190
PNMT Complex Delay	-0.352*	-0.315*
PNMT Overall Delay	-0.487**	-0.323*
df = 31		

* Correlation is significant at the 0.05 level (1-tailed)

** Correlation is significant at the 0.01 level (1-tailed)

3.6 Effects of Age and Education on PNMT, RAVLT and ROCF

Correlations were run to determine the effects of age and education on all assessments. The PNMT was significantly correlated with age and not significantly correlated with education (see Table 11). These results would indicate the PNMT is not affected by education and allows for a more pure assessment regardless of this variable. The RAVLT and ROCF show significant correlations with age and education (see Table 12). This indicates these variables would need to be controlled for when evaluating the variables on results.

Table 11

Correlations for Age and Education with PNMT

	Age	Education
PNMT Delay	0.339**	-.030
PNMT Simple Delay	0.235*	.013
PNMT Complex Delay	0.329**	-.052
PNMT Total	0.319**	-.177
PNMT Simple Total	0.286**	-.103
PNMT Complex Total	0.283**	-.199
N = 67		

* Correlation is significant at the 0.05 level (1-tailed)

** Correlation is significant at the 0.01 level (1-tailed)

Table 12

Correlations for Age and Education with RAVLT and ROCF

	Age	Education
RAVLT Delay	-.159	0.266*
RAVLT Recall	-.168	0.214*
RAVLT Trial Total	-0.278*	0.309**
ROCF Copy	-0.342**	.100
ROCF 3-minute Delay	-0.250*	0.352**
ROCF 30-minute Delay	-0.346a8*	0.307**
N = 67		

* Correlation is significant at the 0.05 level (1-tailed)

** Correlation is significant at the 0.01 level (1-tailed)

3.7 Effects of Alcohol Dependence and Abstinence on Memory

Correlations were computed to evaluate the impact of length of alcoholic dependence on the PNMT. Correlations were run controlling for age and education. The PNMT total, PNMT simple configuration total, and PNMT complex configuration total

were examined and showed no significant correlation present in the abstinent group. Correlations were run for the PNMT total delay, PNMT simple configuration delay, and PNMT complex configuration delay (see Table 13). Alcohol dependence was highly correlated with the PNMT simple configuration delay. The results may be due to challenges with working memory and recall.

Correlations were also computed controlling for age and education between alcohol dependence and abstinence and the RAVLT trial total, recall and delay, as well as the ROCF copy and three- and thirty-minute delays (see Table 14). Alcohol dependence and abstinence were significantly correlated with the ROCF three-minute delay. These results may indicate organizational and recall deficits for this group. Alcohol dependence was significantly correlated with the RAVLT recall task. This again may indicate deficiencies in recall for the group. Alcohol abstinence was significantly correlated with the ROCF thirty-minute delay. This may indicate that there are organizational and recall deficits in this group.

Table 13

Correlations for Alcohol Dependence and Abstinence and PNMT Delays Controlling for Age and Education

Experimental Group	PNMT Total Delay	PNMT Simple Delay	PNMT Complex Delay
Alcohol Dependence	.262	0.409*	.091
Alcohol Abstinence	-.158	-.096	-.152
df = 31			

* Correlation is significant at the 0.05 level (1-tailed)

Table 14

Correlations for Alcohol Dependence and Abstinence - ROCF and RAVLT Controlling for Age and Education

Experimental Group	ROCF Copy	ROCF 3-minute Delay	ROCF 30-minute Delay	RAVLT Delay	R AVLT Recall	RAVLT Trial Total
Alcohol Dependence	.274	-0.319*	-.215	-.208	-0.457**	-.185
Alcohol Abstinence	.017	0.315*	0.369*	.072	.233	.075
df = 31						

* Correlation is significant at the 0.05 level (1-tailed)

** Correlation is significant at the 0.01 level (1-tailed)

CHAPTER IV

DISCUSSION

In assessing for differences in verbal and nonverbal memory and learning in abstinent alcoholics, the current study revealed numerous results. Concerning nonverbal memory, on the PNMT, item difficulty impacted the memory results of the abstinent alcoholics, which showed they had less clear dimensions of recall and learning. Abstinent alcoholics also performed slightly less effectively on the complex designs when compared to controls. On the ROCF, the 3-minute and 30-minute delay results showed significant differences between the abstinent alcoholics and controls with the abstinent alcoholics performing more poorly. The complexity of the ROCF and the measures of organizational visual-spatial elements and memory deficits it provides may be impacted by the nature of suspected frontal lobe deficits resulting from chronic and heavy alcohol use and abuse (Davies et al., 2005). This may occur at the encoding stage due to a lack of successful encoding strategies that include abstraction and synthesis of new information (Dawson & Grant, 2000). It is also consistent with studies indicating

there are white mater changes in the connections between the temporal and frontal lobes (Jernigan et al., 1991; Ruiz et al., 2012).

The RAVLT did not indicate significant differences on the verbal memory recall trials between groups, however, the abstinent alcoholics did perform slightly poorer than controls. The RAVLT is a measure for encoding, storage and retrieval and for type and severity of memory deficits. Surprisingly, in this study, length of alcohol dependence was shown to be a significant predictor of performance on the recollection trial of the RAVLT in the abstinent group. Although this was not an expected result of the study, it is consistent with memory deficits involving the frontal lobes. Recognition examines the capacity to determine when a datum was learned as well as what other data it was learned with at the time of presentation. Deficits in the recognition of learned material may indicate disordered recall as is common in patients with frontal lobe dysfunction. Learning is unable to be tracked in this instance and it is difficult for the patient to make any order out of learned materials (Lezak et al., 2004). Studies have shown a connection between frontal lobe function and alcoholism (Zahr at al., 2010; Desmond et al., 2003).

Additionally, the learning curves for the PNMT and the RAVLT were measured and the performance of the abstinent alcoholics differed slightly from the control group on the complex configurations of the PNMT indicating a trend that nonverbal learning is may be impaired in abstinent alcoholics. There was no difference in learning trials for the RAVLT for verbal memory. Along with the results from the ROCF, this indicates there may be lateralization of deficits with the right hemisphere being more affected by the neurotoxicity of chronic and heavy alcohol abuse than the left hemisphere. This is consistent with prior studies that indicate lateralization of the effects of chronic alcohol

use on memory with the right cerebral hemisphere being affected more than the left (Leber, Jenkins & Parsons, 1981; White, 2003).

Analyses indicated that length of alcohol dependency significantly correlated with the PNMT simple configurations, the RAVLT recall tasks and the ROCF three-minute delay task. This may be a result of challenges with recall and memory globally. Length of abstinence correlated with the ROCF three-minute and 30-minute delays and may be reflective of organizational and recall deficits in this group. In addition, length of alcohol dependence was shown to predict the score on the RAVLT recognition trial. One limitation of the PNMT is that it does not have a recognition trial and the addition of a recognition trial might be helpful for comparison to the RAVLT or other multi-trial learning assessments with a recollection measure. The recognition feature of the RAVLT measures the amount of learning regardless of the retrieval efficiency (Lezak et al., 2004) which can also be measured in the other trials. This may have implications in a clinical population when assessing if a patient is having difficulties in retaining new information or has disordered recall.

In addition to the assessment of verbal and nonverbal memory in abstinent alcoholics, the present study also sought to validate a new nonverbal measurement, the PNMT. The PNMT is a nonverbal measure that prevents sub-vocalization of the assessment tasks and involves multiple trial learning. When a neuropsychological assessment for nonverbal tasks involves the ability to engage verbal mediators, it prevents the ability to validly measure nonverbal memory. Currently, there is no consensus concerning the validity of neuropsychological measurements for nonverbal memory (Wisniewski et al., 2012) and this may be attributable to the ability of subjects to

verbalize certain nonverbal assessment tasks in specific neurological assessment tasks (Wisniewski et al., 2012).

Results of the present study support the test validity of the PNMT for assessment of nonverbal memory. The PNMT offers some unique features. As seen in the abstinent alcoholics, performance on nonverbal assessments varies according to the complexity of the tasks. The PNMT has both simple and complex configurations. Two distinct dimensions resulted from the performance of the abstinent alcoholics and the control group along the lines of complexity. The PNMT simple and complex configurations correlated significantly with the ROCF 3-minute delay and the ROCF 30-minute delay for both the control and experimental groups with the simple configurations correlating less strongly than the complex configurations. This may be interpreted as support for the lateralization of memory deficits in the right hemisphere concerning the nonverbal nature of the assessment. It also supports the hypothesis that the more complex the task, the more difficult the abstinent alcoholic has in completing the tasks. In addition, the PNMT was not mediated by education level as is the ROCF and RAVLT. The would allow the assessment to be administered to varied populations, even the more impaired, as it prevents a floor effect due to the task being too difficult for impaired patients. Finally, patients with impaired grapho-motor skills and executive function deficits will likely be able to be more accurately measured on the PNMT as compared to the ROCF as there is no component of drawing or planning involved.

As was previously noted, the construct validity of the PNMT was also assessed by comparing a current verbal measurement of memory, the RAVLT, to the PNMT. Specifically, the multi-trial aspect of the RAVLT allows for computation of a learning

curve. In addition to evaluating the processes involved in memory encoding, storage and retrieval, as well as modality-specific abilities, the impact of repetition of material on recall is important. Currently, no other neuropsychological assessment of nonverbal abilities measures both memory and learning congruently. The PNMT allows for measurement of nonverbal learning and this provides more information concerning clinical populations as to various types of deficits of patients. Consequently, the ability to compare both memory and learning for both modalities in a similar fashion such as learning trials, similar stimuli amounts and format, affords the opportunity to differentiate between left and right hippocampal deficits.

The learning curves of the PNMT and RAVLT show similarities between the two assessments for both the abstinent alcoholics and the controls. Total learning across the five trials is significantly related. As mentioned, this may allow for clinicians to utilize additional information to assist in distinguishing between hemispheric specificity concerning brain damage and disorders. Operationally, memory and learning are different constructs. The ability to utilize learning curves allows for the assessment of acquisition rates (i.e. learning slopes). The ability to evaluate memory disorders for more specific functional recommendations can be accommodated with repetition of presented materials and thus learning within the neuropsychological assessment. Also, total learning can be compared to a learning curve allowing for differentiation between a person's ability to learn at all versus slow learning. These aspects are important when evaluating for dementia for instance. It allows for a temporal comparison of a patient's declining ability to learn. Complexity may also be a factor to consider when evaluating learning. Future studies should focus on considering this aspect in depth. The ability to

compare both types of material may lead to a differential diagnosis in clinical populations such as patient's suffering from strokes, traumatic brain injury or epilepsy.

Some of the limitations of the present study are worth mentioning. First, the sample was assessed on neither executive function nor IQ. This would have been helpful in assessing the strategy for completion of the ROCF in particular for a measure of executive function. There were also limitations on age as logically, the younger a person, the less abstinence they will have accumulated over time. This sample also consisted of a wide variety of lengths of abstinence and different results could have occurred if using a sample with a less varied amount of abstinence from alcohol.

Additional measurements in other clinical populations would also be advised to determine any clinical implications of the PNMT. First, patients with lateralized brain insult such as traumatic brain injury, surgical interventions for tumors or epilepsy with right or left-sided foci should be assessed for further validity. Second, it would be advisable to assess Alzheimer's patients at the beginning of the disorder as well as to follow the patients through the various stages in order to validate the measure's ability to identify memory and learning deficits. The addition of a recognition trial may be helpful on the PNMT as this would then allow for more measurements to be obtained.

The results of these neuropsychological assessments indicate that even with long-term abstinence, residual deficits are present in abstinent alcoholics. This is consistent with some studies (Davies et al., 2005); Brandt, Butters, Ryan & Bayog, 1983) and not with others (Rosenbloom et al., 2007; Pitel et al., 2009; Bartels et al., 2007). Nonverbal memory is affected more so than verbal memory in the present study. The only verbal measurements that is significantly affected by length of alcohol dependence was the

recollection measurement on the RAVLT. These neuropsychological results have implications for the treatment of alcoholics in both treatment and rehabilitation facilities. Transferring the treatment concepts presented while detoxifying from alcohol and applying problem solving techniques to maintaining abstinence become critical in the recovery from chronic alcoholism.

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