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THE POREH NONVERBAL MEMORY TEST

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THE POREH NONVERBAL MEMORY TEST

CHELSEA K. KOCIUBA

ABSTRACT

Nonverbal memory focuses on the remembrance of information that cannot be described or put into a verbal component, such as remembering a person's face, identifying abstract stimuli, or remembering objects. Because nonverbal memory focuses on the remembrance of things that cannot be put into words it is a difficult construct to measure accurately. One area that is of great importance in the assessment of nonverbal abilities is spatial memory (Reynolds & Coress, 2007, Foster, Drago, & Harrison, 2009). Most of the tasks that have been developed to assess this construct employ verbally mediated clues allowing the examinee to compensate for their performance using verbal strategies. These measures often rely on planning and organizational (executive) abilities, which should be viewed as a separate construct. One prime example of such a task is the Rey Osterrieth Complex Figure. This test requires grapho-motor skills, intact planning abilities, and it also allows for verbal mediation. The present study examined the utility and validity of a new novel spatial memory test, the Poreh Nonverbal Memory Test. The preliminary data shows that the test acts in a similar fashion as auditory verbal learning tests. Namely, during the repeated presentation of the test stimuli, examinees show a logarithmic learning curve. Additionally, the performance correlates with existing measures of visual spatial, supporting its validity in assessing the purported construct.

Given the preliminary nature of this study additional research is needed, using clinical populations with lateralized head injuries and executive function impairment to assess the validity of the new test.

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CHAPTER I

INTRODUCTION

1.1 Cognitive basis of memory

Memory is the foundation of human functioning and interaction. It provides a basis to take in information and store it over short and long periods of time in order for people to better adapt to the environment. Memory, however, is not a simple task of taking in information and putting it into reserve. On the contrast, memory is a several stage model that consists of processing information and then rehearsing it in order for it to be put into long term storage (Thompson, 1987). Furthermore, memory is broken up into different domains dependent on its type and functional use.

Evidence, supporting memory as a several stage model is reinforced by studies of brain substrates, particularly that of a famous brain surgery on HM who underwent surgical treatment to correct seizures caused by epilepsy. The surgery performed on HM removed portions from each of his temporal lobes, which included portions from the hippocampus and amygdala in both hemispheres of his brain (Thompson, 1987). Subsequently, after the surgery, HM lost his ability to remember his own experiences and was unable to hold new information in memory for more than a few seconds if he was

distracted (Thompson, 1987). His memory for short term information was normal, but he was no longer able to store information into long-term memory. HM, however, did exhibit normal memory for motor skills. The study on HM and patients like him support that there are two different kinds of long-term memory systems and a short-term memory system.

Memory can be further broken down by how it is encoded. The process is first started when sensory information enters the brain. There, the information is attended to and put into short term memory (Anderson, 2005) where the brain processes the information. Short term memory or what Baddeley coined as working memory has a limited capacity (1966, Anderson, 2005). Information is continuously entering the brain and pushing out old material requiring short-term memory to store the information into long term memory or to abandon the information obtained.

It was postulated by Baddeley that the brain is able to keep about 1.5 to 2 seconds worth of material rehearsed at a time in the articulatory loop of short term memory (1986). Information that is obtained through sensory input is processed at the speed in which the brain can rehearse the information and evidence for such has been found by the word-length effect (Baddeley, Thomson & Buchanan, 1975). The study examined subjects that read 5, one syllable words and 5, five syllable words. The subjects were able to recall 4.5 out of the 5 words that were one syllable, but were only able to recall 2.6 words out of the 5 for five syllable words, showing that the time it takes to process information takes away from the brains ability to keep additional information intact and to convert it to long term memory. An additional study by Miller described

short term memory as “the magic number seven, plus or minus two” where the average population can attend to about 5-9 items of information at a time (1956).

Despite that there is only a limited amount of information that can be held in short-term memory, once the brain rehearses the information and encodes it into long term memory, the capacity of information the brain can hold is limitless (Thompson, 1987). Long-term memory is divided into two main categories declarative (explicit) and non-declarative (implicit) memory (Anderson, 1976).

Declarative memory can be thought of as answering the question “what”, where it holds information for the knowledge on facts of people, places and things and the meaning and interpretation of these facts (Sharma, Rakoczy, Brown-Borg, 2010).

Declarative memory can be further broken down into episodic and semantic memory. Episodic memory consists of information that is of a personally experienced event that can be traced to the place and time of the occurrence (Sharma, Rakoczy, Brown-Borg, 2010). Semantic memory encompasses knowledge for facts that are learned outside of an independent context, such as information learned from reading a book (Miller 1956, Tulving 1972).

Non-declarative memory includes information of the “how” nature. This type of memory includes tasks of a procedural nature, which includes the acquisition of motor skills and habits, such as riding a bike or playing tennis (Bechara et al., 1995; Knowlton et al., 1996; Salmon and Butters, 1995). Non-declarative memory has been coined “Procedural Memory” by Squire, who discussed how motor skill learning is different from declarative memory (1987). Squire claimed that due to the complex nature of movements in sports that the movements required autonomic practice to acquire

efficiency. The ability to think about the movements is not good enough, and therefore the physical remembrance of a movement is encoded in a different portion of the brain.

Lastly, the encoding of memory can be broken down further into the modality used for encoding. Typically, researchers distinguish between tasks that employ verbal and visual stimuli. Visual memory tasks encompasses skills such as remembering and recognizing the faces of people, or remembering the location of an object, while verbal memory tasks consists of processing information that can only be verbally encoded, such as a friend's name or vocabulary (Thompson, 1987). The importance in distinguishing between the two types of memory lies in how each type of information is programmed. Verbal memory and the remembrance of auditory information depends specifically on the subvocal rehearsal of items (Hwang et al., 2005) while visual information is programmed through contextual cues.

1.2 Anatomical basis of memory

The human brain is composed of two hemispheres, each specializing in the integration and analysis of different types of information. Multiple studies have shown that among most individuals the left hemisphere primarily analyzes verbal information whereas the right hemisphere mainly analyzes nonverbal information (Anderson, 2005). The reason for the existence of two separate hemispheres is to improve the brains efficiency by employing parallel processing. Within the medial portion of the two hemispheres lies the hippocampal formation. The left hippocampal formation has been repeatedly shown to encode and lay down memory for verbal information, such as word encoding, whereas the right hippocampal formation has been repeatedly shown to encode

and lay down nonverbal information, such as facial coding (Foster, Drago, & Harrison, 2007, Duncan & Koeppe, 2007). Larry Squire for example showed that patients with right hippocampal formation damage exhibited nonverbal memory deficits, while patients with damage to left hippocampal formation show difficulties in laying down verbal information into long term storage (1977).

The medial temporal lobes structures (MTL), specifically the hippocampus, are also important components of declarative memory for recognizing past experiences (Jeneson, Krwan, Hopkins, Wixted, & Squire, 2011) and encoding memory (Duncan & Koeppe, 2007). The hippocampus plays a substantial role in recollection while other areas in the MTL cortex are dependent on familiarity (Brown & Aggleton, 2001, Mayes et al., 2002, Yonelinas et al., 2002). Bilateral damage to the medial temporal lobe structures have 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 & Cohen, 2001, Squire, Stark & Clark, 2004).

Additional studies on nonverbal components have also supported hippocampal activity within the brain during spatial measurement tasks. One study in which subjects had to perform a navigational task in a virtual town demonstrated high activity in the hippocampus (Bohbot et al., 2004, Maguire et al., 1998) while another similar study on licensed London taxi drivers found that drivers who had extensive navigational experience were found to have a superior hippocampal gray volume compared to controls (Maguire et al., 2006). Furthermore studies on human subjects and animal subjects show that hippocampal damage due to brain lesions or age-associated changes demonstrate

impaired learning on spatial memory tasks (Abrahams et al., 1997, Bannerman et al., 1999).

1.3 Assessment of Memory

The verbal/nonverbal dichotomy in the processing of information by the brain has lead neuropsychologists to seek out measures that will differentially tap into these constructs. Typically, the measures that neuropsychologists adopted for this process were taken from early psychological studies. Often these measures do not take into account the modality differences of the major aspects of the memory system.

The best example of such a measure is the Wechsler Memory Test. This test employs multiple simplified geometric drawings that have been adopted from Binet's Intelligence Test (1906). Therefore inherent in this task is the assumption that the intellect of the subject is intact, particularly the grapho-motor skills while coping the designs, which include circles, squares and triangles. If a subject is unable to properly copy these figures due to either grapho-motor deficits or difficulties in planning than it is given the subject is unable to recall the figures. Moreover, since the procedure involves one trial of copying the figures and then a 30 minute delay recall, the Wechsler memory scale is not suitable for assessing nonverbal learning.

Once the testing is completed the very cumbersome scoring procedure ensues. Studies show that as a result of the scoring complexity the inter scorer reliability coefficients for these tests are often quite low (Woloszyn et al., 1993). Moreover, studies show that the Wechsler Memory Scale is not sensitive to either left as opposed to right hemisphere damage (Chelune & Bornstein 1988), nor is it sensitive to distinguishing

from patients with lateralized temporal lobe epilepsy (Barr, Chelune et al., 1997).

According to the literature, the nature of the designs encourages the subjects to employ verbal strategies to encode the data, limiting the performance differences between right and left brain damaged patients (Jones-Gotman, 1991). As in most current measures that assess memory, the subjects are not alerted that when given the copy instructions that they will have to reproduce the figures from memory. Therefore, subjects who are not attentive may perform poorly in the recollection stage of the test.

Another commonly used measure for assessing nonverbal memory is the Complex Figure Test (CFT). A number of variations of this test exist, including the Rey Osterrieth Complex Figure (ROCF, Rey, 1941, Osterrieth, 1944), the revised Taylor Complex Figure (RTCF, Hubley, 2002) and the Medical Center of Georgia Complex Figures (MCG, Loring et al., 1990). Much like the Wechsler Memory test, all of these tests involve a copy stage, followed by delayed recall and recognition of the figure. Given the nature of this paradigm, all of these tests suffer from the same limitations of the Wechsler Memory Scale. Namely, normal subjects or patients with impaired grapho-motor skills, executive function deficits, and tendency to use verbal mediation to encode and recall the stimuli may not be accurately assessed using such measures.

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 and Harrison, 2009). A good measure of visuospatial 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.

1.4 Assessment of memory in rodents

The assessment of visual spatial memory in animals involves paradigms that do not rely on either planning or grapho-motor skills. The first of such paradigms was employed by Edward Tolman (1948) to study rats. Tolman placed rats in a maze that consisted of paths and blind alleys and provided them with rewards for accomplishing the task. Tolman observed that damage to hippocampal formations resulted in the inability of the rats to obtain spatial information over repeated trials (Tolman and Gleitman, 1949). Since this initial experiment, multiple studies have been used to assess the spatial memory of rodents using various paradigms.

One paradigm that has gained popularity is the Morris Water Maze (Morris, 1984). This paradigm involves the use of a round pool filled with water, made opaque using milk and or white paint. The rodent is placed randomly inside the pool and has to locate a platform that is hidden underneath the water. The procedure is repeated a number of times until the animal is able to learn the hidden location of the platform using distal cues. With time, the latency to locate the platform decreases, indicating that the rodent has learned the maze.

Studies show that mice employ three types of strategies to locate the hidden platform (Brandeis et al., 1989); a praxic strategy composed of having the animal learn the sequence of movements required to reach the platform, a taxic strategy which is used when the animal uses cues or visual proximal guides to reach the platform, or a spatial

strategy in which the animal reaches the platform according to the spatial configuration of the distal cues. Studies repeatedly show that the Morris water maze permits the accurate and reproducible study of reference memory, spatial working memory and learning (D'Hooge and De Deyn, 2001; Dudchenko, 2004). They also show that this test is highly sensitive to hippocampal damage (Morris et al., 1982), as well as to age related decline in spatial memory in mice (Zhao et al., 2009 for review of this topic).

1.5 Development of the Poreh Nonverbal Memory Test

The Poreh Nonverbal Memory Test (PNMT) was designed on the same premise of existing visual spatial memory tests of rodents, in particular the Morris Water Maze. In the core of this paradigm is the assumption that the hippocampal formation involves the process of learning and laying down new memories. Therefore, any test of nonverbal memory should include multiple, repeated presentations of the same stimuli.

Additionally, given the anatomical link between the frontal lobes and the hippocampal formation it is fundamental in the development of this measure to limit the role of organizational and planning skills when performing this test. In other words, the goal was to develop a pure measure of visual spatial memory that would correlate with the right hippocampal formation.

The PNMT mirrors the Morris water maze by employing similar strategies in which nonverbal stimuli are to be encoded. Similar to the Morris water maze, there are hidden figures that are to be found and remembered by the subject engaged in the test. Nine cards are presented over five trials, in which a hidden red square is to be learned and recalled more effectively after each subsequent trial. Subjects are to use similar strategies

to the Morris water maze, specifically a spatial strategy where subjects are to use spatial and distal cues to locate the hidden red box. The PNMT allows for a reproducible and accurate study of spatial working memory, reference memory and learning.

1.6 Hypothesis

The goal of the study was to (1) Collect preliminary norms for the Poreh Nonverbal Memory Test (2) Assess whether subjects who are administered the test exhibit the same learning curve as that of existing verbal memory measure. Namely that it will exhibit a logarithmic learning curve, much like the one observed on the Rey Auditory Verbal Learning Test (3) Assess whether the new measure possesses construct validity and differentially correlates with existing verbal and nonverbal memory test. 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 51 college students at a Midwestern university. 76.5% of the subjects were females, 68% were Caucasian, 25% were African American, 2% Asian, and 3.9% Hispanic. The average age of the subjects was 21.3 (SD=5.9). The average level of education of the subjects was 13.54 (SD=1.79).

2.2 Measures

Rey Auditory Verbal Learning Test (RAVLT)

The RAVLT is a neuropsychological test of verbal learning and episodic declarative memory (Magalhães and Hamdan, 2010), and was developed in the 1940s. Its purpose is to produce scores that measure new verbal learning, immediate memory, vulnerability to interference, memory recognition and retention of information (Van der Elst,

Van Boxtel, Van Breukelen, & Jolles, 2005). The RAVLT is used in many settings and is sensitive to numerous neurological impairments and verbal memory deficits (Spreen & Strauss, 1998). In the present study a computer administered version of the test was used.

The RAVLT is an instrument that contains 15 words that are read aloud to the subject at a rate of one word per second. The words are given over five consecutive trials and each trial is ensued by a free recall period upon which the participant names as many words as they can extract. After completion of the fifth trial an interference list consisting of 15 new words is given in the same method as the first list followed by an additional free recall list. A subsequent sixth trial is given in which the examinee is requested to evoke as many words from the initial list. Following is a 30 minute delay period, upon after the examinee is once again asked to remember the original list one more time. Lastly, a recognition list is presented verbally to the participant in which the examinee has to identify if the words presented was from the primary list or not (Rosenberg, Ryan & Prifitera, 1984).

Rey Osterrieth Complex Figure Test

The ROCF was first designed in 1941 by Rey and was then normalized in 1944 by Osterrieth (Gagnon, Awad, Mertens, and Messier, 2003). It was originally designed as a construct that would differentiate between inherited and acquired mental deficiencies (Hubley & Tremblay, 2002). However, it eventually became used as a method of measuring visual memory and perceptual organization in adults who had suffered from brain damage (Hubley & Tremblay, 2002). Current uses of the ROCF are to assess visuospatial construction, drug treatment, rehabilitation, learning, and memory (Hubley

& Jassal, 2002). This can be applied to a variety of cases, such as assessing a person's learning and memory before and after a brain surgery, assessing the impact of a stroke on perceptual impairment, or evaluating drug treatments on memory (Hubley & Jassal, 2002).

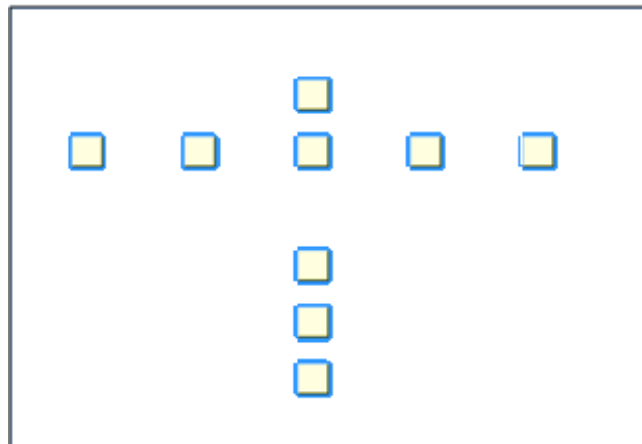
In traditional administrations of the test examinees are first shown the figure and are asked to copy it while viewing it simultaneously. After copying, the figure is taken away, and the examinee is asked to reproduce the figure from memory. The time in which the examinee is asked to reproduce the figure can vary. The examinee may be asked immediately to reproduce it, or can wait anywhere from 5-40 minutes. The examinee always remains uninformed that they will have to remember the figure for a latter time in order to assess the quality and amount of information retained, and to assume that the information that is recalled is learned incidentally during the copy trial (Hubley & Jassal, 2002, Hubley & Tremblay, 2005).

The Poreh Nonverbal Memory Test

The PNMT is a new test designed by Amir Poreh that is intended to better measure nonverbal, spatial memory. Participants are given the test via a computer assisted administration with an examiner present for assistance with software. The test consists of nine similar items and five trials. On administration of the first trial, participants click on white boxes until red appears in the box. Once the red box is established, it remains in place for several seconds in order for the participant to commit the location to memory. After this, the next screen becomes available and the cycle repeats until all nine items are completed. The next four trials consist of attempted recall

of the red square in each of the nine items. The computer records correct and incorrect responses for each item for each trial. It also records how many errors occur in each item search, until the correct box is identified. The computer then generates a learning curve based on the first five items and then delayed recall is determined from a sixth trial administered. Figure 1 displays one of the items on the PNMT in which participants are shown.

Figure 1: Item 1 on the PNMT



2.3 Procedure

Participants were recruited through Cleveland State University's Sona-Systems in which students can participate in research for class credit. After providing informed consent, participants provided basic demographic information. Participants were then administered a collection of neuropsychological tests which consisted of the ROCF, the RAVLT and the PNMT. The ROCF was administered first, consisting of the copy, immediate trails. Participants then completed the first five trial of the RAVLT, and then

the first five trials of the PNMT. Subsequently, the delays for the ROCF, RAVLT, and the PNMT were given in listed order.

2.4 Data Analysis

The validity of the PNMT was examined through several different analyses. Statistical analyses were comprised of comparing the validity and reliability coefficients to the well established non-verbal test of memory, ROCF. The correlation between the verbal and nonverbal measures were recorded and a logarithmic learning curve for the RAVLT and the PNMT were compared. Total learning for the PNMT and RAVLT were also examined and compared. Multiple regressions were conducted for age and gender, specifically a stepwise multiple regression. Regression based norms were also created for age, education, and gender.

CHAPTER III

RESULTS

3.1 Preliminary norms

Descriptive statistics were run for the five learning trials and delay trial on the PNMT in order to determine the range of hit distribution for each trial as well as to determine the mean, standard deviation, skewness and kurtosis. On each learning trial, the minimum and maximum variables highlight the range of items hit over the nine cards presented. The mean represents the average number of hits it took a subject to find the red square for all nine cards on each trial, and is the indicator of learning over the five total trials and memory for the delay trial. 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 are shown in Table 1.

Table 1

PNMT Learning Trials-Descriptive Statistics

	Minimum	Maximum	Mean	Std. Dev	Skewness	Kurtosis
Poreh Trial 1	31	66	49.5	7.7	-.076	-.380
Poreh Trial 2	14	51	31.7	10.5	.190	-1.027
Poreh Trial 3	9	51	25.5	8.9	.490	.724
Poreh Trial 4	9	55	22.9	9.7	.974	1.280
Poreh Trial 5	9	45	19.0	8.4	1.257	1.941
Poreh Delay	9	39	16.9	6.9	1.261	1.527

N=51

3.2 Graphs

Histograms for the PNMT-Total Delay, the ROCF Delay and the RAVLT Delay were examined in order to determine the complexity of memory measurement for each test. The histogram for the PNMT (Figure 2) 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 RAVLT (Figure 3) mirrors the PNMT in the opposite direction, as it is negatively skewed. The change of skewness is a result of scoring higher on the RAVLT to be a better indicator of memory, while scoring lower on the PNMT is a better gauge of memory. The RAVLT also shows to be a good measure of verbal memory, and that normal's should perform more highly. Lastly, the ROCF (Figure 4) had a graph that was more evenly distributed. This visual representation shows that the task is more difficult

than the PNMT or the RAVLT and leaves more room for my error in assessing nonverbal memory.

Figure 2: PNMT Delay Distribution of Scores

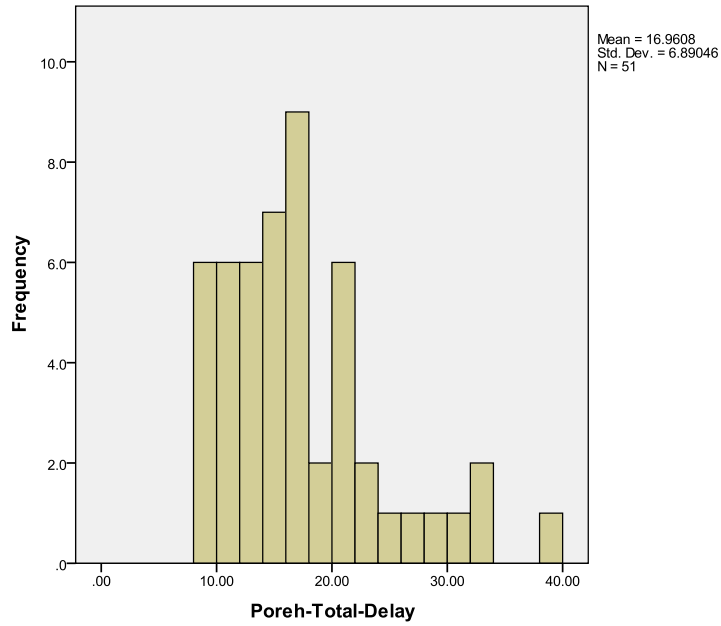


Figure 3: Rey Auditory Delay Distribution of Scores

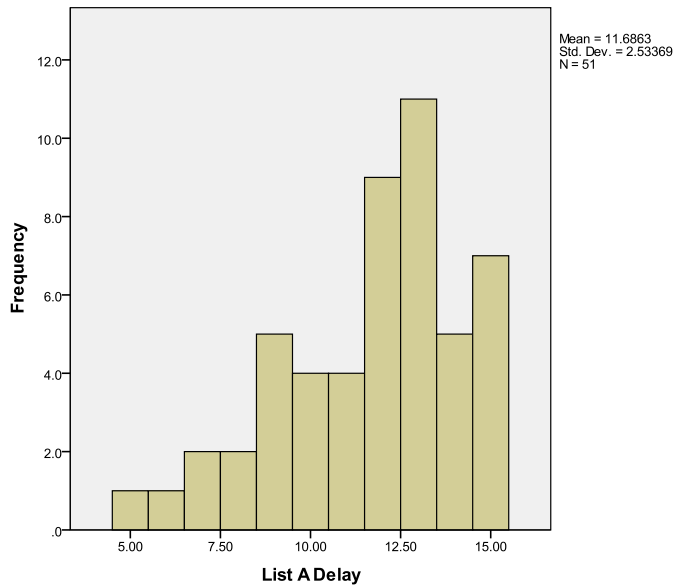
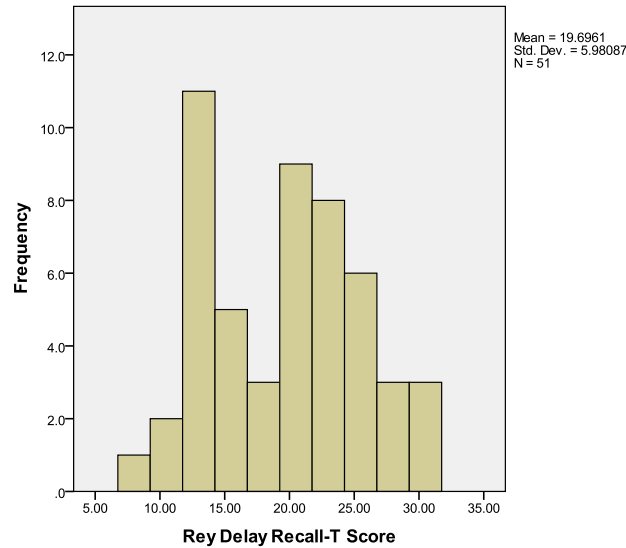


Figure 4: Rey Complex Figure Delay Distribution of Scores



3.3 Item Difficulty on the PNMT

A principal components factor analysis was run on the nine items from the PNMT in order to group the items by difficulty for the purpose of differentiating between difficult and easier items. Items that loaded on factor one were card numbers 1, 2, 4, 7 and 9 while items that loaded on factor two were card numbers 3, 5, 6 and 8 (see figure 5, table 2). It was determined that items that loaded on factor one were of a more difficult nature than items that loaded on factor two. The difficulty of these items lies on the premise that the design of each card on factor one was of a random blueprint compared to items on factor two that had an organized design pattern.

Correlations for factor one and two were run to compare the relationship with the ROCF. Items that loaded on factor one significantly correlated with the ROCF at the .01 level and items on factor two loaded significantly with the ROCF at the .05 level showing the items on the PNMT to effectively measure nonverbal memory and to parallel the

difficulty of the RCFT (see table 3). It was predicted that items on factor one would correlate more highly with the RCFT due to the more difficult nature of the items.

Figure 5: Factor Analysis of Item Difficulty on PNMT

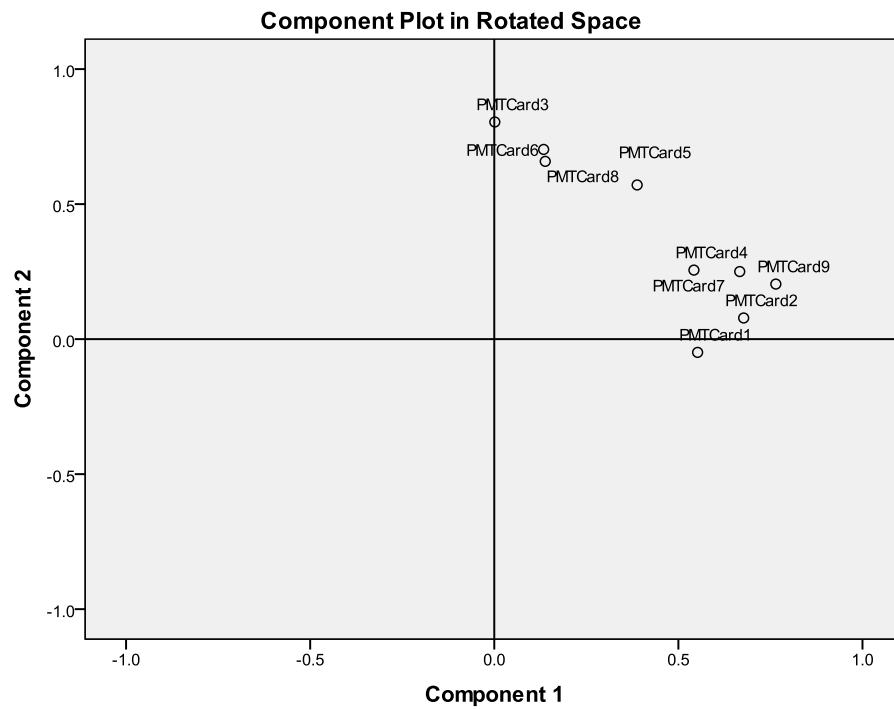


Table 2: Factor Loadings

	Component	
	1	2
PMTCard1	.552	-.049
PMTCard2	.677	.078
PMTCard3	.001	.804
PMTCard4	.542	.256
PMTCard5	.388	.571
PMTCard6	.134	.703
PMTCard7	.667	.250
PMTCard8	.138	.658
PMTCard9	.765	.204

Table 3

Factor Correlations

	Factor 1	Factor 2
Rey-Immediate	-.327**	.174
Rey-Delay	-.415**	-.004

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

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

3.4 Learning Curve

Total learning across all five trials of the RAVLT and the PNMT were computed and then correlated to determine the learning relationship between the two tests. Total learning was computed by summing the total number of words learned across all five trails on the RAVLT and summing the number of hit-rates obtained on the PNMT on all five learning trials. 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 4). 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. Logarithmic learning is computed by 80% learning over each subsequent trial. The PNMT showed a log series with an R-squared of 0.9678 showing it to be a significant predictor of nonverbal learning across five trials. A logarithmic learning curve was also computed for the RAVLT to determine learning over five trials in which a log series with an R-squared of 0.9899 was computed, showing it to be an almost perfect predictor of verbal learning and memory (see figures 6 and 7).

Table 4

Correlations for total learning on RAVLT and PNMT

RAVLT	PNMT
N=51	-.468**

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

Figure 6: PNMT Learning Curve

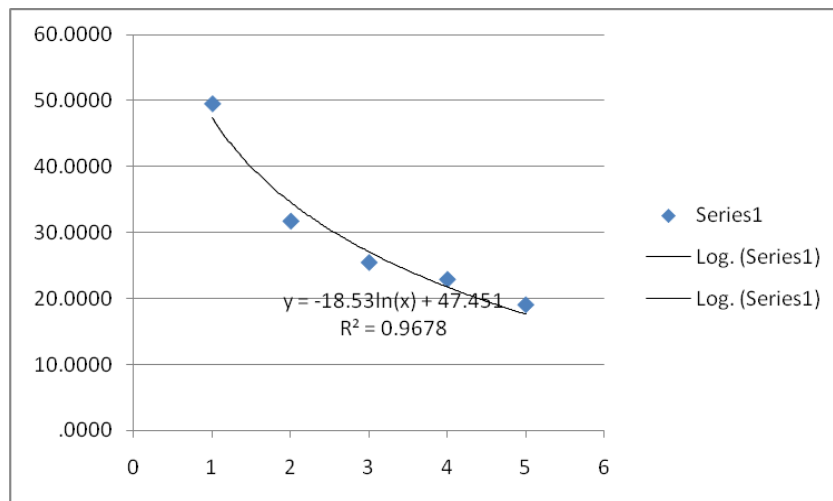
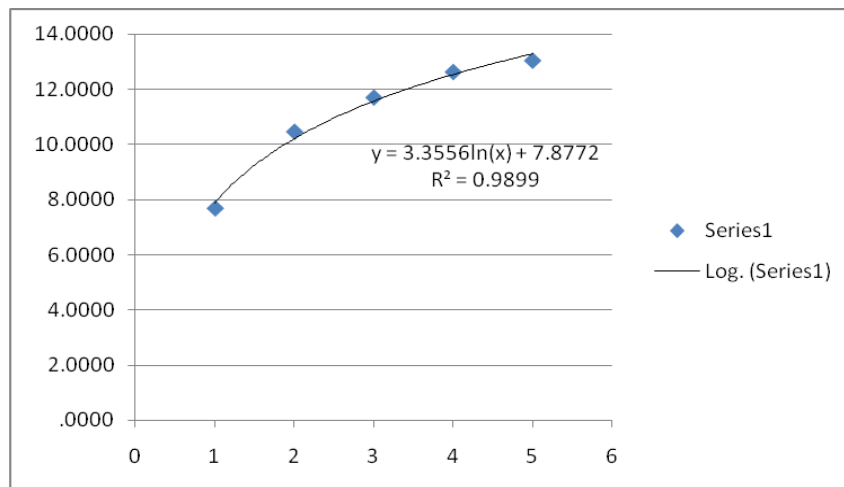


Figure 7: RAVLT Learning Curve



3.5 Construct Validity

Construct validity was determined by running multiple correlations. As was previously shown the first measurement showed that the PNMT-total delay correlated negatively with the Rey-Immediate at the .05 level and the Rey-Delay at the .01 level. This relationship shows that the PNMT is a good measure of nonverbal memory as it correlates with an existing measure of nonverbal memory. Correlations are marked by the way each of the tests measure memory. High scores on the Rey Complex Figure are indicative of a better score and more sufficient nonverbal memory, while low scores on the Poreh Nonverbal Memory Test support a more superior score and satisfactory nonverbal memory. Additionally, the PNMT-total delay correlates with the RAVLT Delay. This is important as it shows that the PNMT follows the same type of learning pattern that the RAVLT follows.

The PNMT trials 1-5 which accounts for total learning over the test also correlates with RAVLT total learning over trials 1-5 at the .01 level which shows the test to be a good measure of total learning over subsequent trials. Lastly the PNMT first learning trial (2-1) significantly correlated with RAVLT first learning trial at the .01 level.

Correlations can be referenced in Table 5.

Table 5

Correlations for PNMT, ROCF and RAVLT

	Rey Immediate Recall-T Score	Rey Delay Recall-T Score	List A Delay	RAVLT 1-5	RAVLT Trial 1
Poreh-Total-Delay	-.288*	-.454**	-.288*	-.236	-.120
Poreh 1 - 5	-.081	-.252*	-.192	-.356**	-.324
Poreh Trial 2-1	-.023	-.081	-.052	-.373**	-.398**

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

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

CHAPTER IV

DISCUSSION

The PNMT is an attempt to develop a Morris Water Test equivalent measure for humans. Namely, that it is a nonverbal measure that is devoid of verbal cues and involves multiple trial learning. The results of the present study support the test validity and display some of its unique characteristics. The first characteristic is the distinction between easy and difficult test items. The present study shows that the two types of items from two distinct dimensions and that the difficult items correlate more significantly than the easy items with the ROCF learning trials. By making the above distinction one might be able in the future to make more fine analysis of the deficits displayed by lateralized brain injured patients, and even perhaps whether the right hippocampal formation takes a greater role in the learning of the difficult items (which are random) while the easy items are more susceptible to verbal mediations (organized stimuli that are able to detect objects or geometric designs). The test is also able to extend down to more impaired patients, preventing a floor effect due to the task being too difficult for impaired patients.

As was previously noted the construct validity of the test was assessed by comparing a current measure of nonverbal memory to the PNMT as well as looking at its

relationship to a verbal measurement of memory. The relationship between the nonverbal and verbal tests not only determines that it is a good measure of nonverbal memory, but that its ability to relate to a verbal measure of memory and learning shows that it is also a good indicator of learning. This is another unique aspect of the PNMT as no other test of nonverbal memory in humans' measures learning congruently. Currently, there are tests that measure nonverbal memory, but there are none that measure nonverbal learning. The introduction of a test that is able to measure both constructs is important as it will provide more information to clinicians about different types of brain damage that patients are suffering from. Also, the ability of clinicians to compare a nonverbal and verbal test of memory and learning that are given in the same type of fashion (aka number of learning trials, number of stimuli, and format) is important as it can help to better differentiate between left and right hippocampal damage.

The present study also demonstrates total learning across all five trials of the test and demonstrates a significant relationship with the RAVLT total learning. This is notable as the tests ability to measure total learning as well as a learning curve can provide clinicians with an additional piece of information in distinguishing between different types of brain damage and disorders. For example, being able to identify total learning as compared to a learning curve is important as it can differentiate between a person's ability to learn at all versus slow learning. This can be vital in testing patients who have dementia, as it can plot over time the person's decrease in ability to learn. The test can also be useful in differential diagnosis as it could confirm a diagnosis of Alzheimer's disease, since both cerebral hemispheres are generally damaged (Zec,

1993), or it can lead to additional inquiries if only nonverbal or verbal learning occurs, such as a stroke.

Finally, it is determined that the PNMT is a superior measure of nonverbal memory compared to the ROCF as it has the ability to better measure nonverbal memory and offer more information than the ROCF. One way in which the PNMT is superior to the ROCF is that it is able to better assess nonverbal memory by allowing subjects to better learn the stimuli. Subjects or patients with impaired grapho-motor skills and executive function deficits are predicted to 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.

Some of the limitations of the present study are worth mentioning. First, the sample was of a limited composition. The sample was constructed of college students, making it difficult to generalize to other age levels and educational levels. Future studies are encouraged to test participants of different age and education levels to try and find more variability and to have a sample size that is more representative of the population.

Furthermore, the administration of the tests was counterbalanced. We did not evaluate the measure of any clinical populations. Additional studies are needed prior to the clinical implementation of the test. First, studies need to examine patients with lateralized brain injury and/or epilepsy. Second, it would be advisable to assess the measure's ability to identify Alzheimer's patient at the very early stages of the disease.

Future research is also needed in order to study the strategies that people use to remember and memorize the location of squares, just as rats use to remember the location of the platform. These strategies include a praxic strategy where the person learns the

sequence of squares required to find the red square, a taxic strategy where the person uses cues or visual proximal guides to reach the platform, or a spatial strategy in which the person finds the red square according to the spatial configuration of the distal cues.

Finally, it would be advisable to collect cross sectional age stratified data.

In sum, the findings in this study suggest that the PNMT is an accurate measure of nonverbal memory and learning. Although there are other measures of nonverbal memory currently in use such as the ROCF the advantage of the PNMT is that it can provide additional measure of learning and memory that the ROCF cannot. Furthermore, the PNMT can be used in conjunction with other existing measures of nonverbal and verbal memory to better diagnosis and differentiate between brain damage and dementing disorders. The study also provided preliminary norms to support the validity of the PNMT in measuring nonverbal memory and learning in normal subjects. The next phase of research would be to examine patients with brain injury and dementing diseases in order to determine its use in detecting different cognitive disorders.

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