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The Clinical Utility of a Short Form Version for the Rey Complex Figure Test (RCFT) in Identifying Visual Memory Impairments with Older Adults

Adam D. Christmann
Philadelphia College of Osteopathic Medicine

Philadelphia College of Osteopathic Medicine

School of Professional and Applied Psychology

Department of Clinical Psychology

THE CLINICAL UTILITY OF A SHORT FORM VERSION FOR THE REY COMPLEX FIGURE TEST (RCFT) IN IDENTIFYING VISUAL MEMORY IMPAIRMENTS WITH OLDER ADULTS

By Adam D. Christmann, M.S., M.S.

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Abstract

The aim of this study was to examine if a short-form version of the Rey Complex Figure Test (RCFT-SF) was equivalent to the measure's standard administration procedures as part of a neuropsychological battery for testing visual memory in an older adult population as well as the impact of anxiety on their performance. The RCFT-SF consisted of a similar administration procedure to the standard form (e.g., copy, immediate recall, delayed recall, and recognition trial) while reducing the period between the immediate and delayed recall portions of the measure to 10 minutes. Participants involved with this study were divided into two groups, the RCFT-SF group and a control group consisting of individuals that were already tested with the standard Rey Complex Figure Test (RCFT). Results from an independent samples *t*-test for the delayed recall trial indicated there was no significant difference between the two measures suggesting the shortened delay period on the RCFT-SF is equivalent to the delay period in the standard RCFT. Non-parametric testing indicated participants in the RFCT group had significantly higher scores than the RCFT-SF group on the copy trial, while there were no significant differences were identified between the two measures on the immediate and recognition trials. When examining the impact of both state and trait levels of anxiety on performance during the RCFT-SF, correlational analyses indicated there was no significant relationship found. Finally, a series of independent samples t-tests found that level of impairment did not impact performance on the scores for the delayed and recognition trials on the RCFT-SF. However, impaired individuals scored significantly lower than those in the unimpaired group on the immediate recall trial for the RCFT. While the limited sample size impacted the results in determining equivalency to the RCFT across all trials, these findings suggest the shortened delay

period in the RCFT-SF produces equivalent scores to the standard administration procedure in terms of the delay period.

CHAPTER 1: INTRODUCTION

Statement of the Problem

One of the most frequently used measures to assess visual memory and perceptual organization is the Rey Complex Figure Test (RCFT), which has become a standard component used in many neuropsychological batteries for individuals with neurocognitive disorders and brain injuries (Camara et al., 2000; Fastenau et al., 1991; Kaplan, 1988; Lezak, 1983, 1995; Orsini et al., 1988; Rabin et al., 2005; Rey & Osterrieth, 1993; Strauss et al., 2006; Squire, 1986; Weintraub & Mesulam, 1985). Since its development, many clinicians use some variation of the instrument's administration procedures during a neuropsychological evaluation (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019). The most common administration for the RCFT is comprised of asking the patient to copy a complex geometric design on a blank sheet of paper and tracked by the examiner. This initial trial is followed by a brief 3-minute delay, after which the examiner provides a new sheet of paper and asks the patient to reproduce the design. A longer delay of approximately 30 minutes is then given before the patient is asked to recreate the image again from memory (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019).

Meyers and Meyers (1995) introduced a recognition trial as a supplemental measure to the initial copy and recall trials that is administered immediately following the long delay. The recognition test is comprised of 24 geometric shapes, consisting of 12 target figures and 12 foils, and requires the patient to identify the various components that make up the initially presented design (Meyers & Meyers, 1995; Rai et al., 2019). The primary function for the recognition task in the RCFT is to assess whether the patient is experiencing problems with retrieving information from memory rather than having difficulties encoding and storing it (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019; Schwarz et al., 2009). This would indicate that with

the help of additional cuing or prompting the individual would be able to more efficiently access information from memory (Fastenau et al., 1991; Schwarz et al., 2009). The recognition trial for the RCFT also helps identify whether the patent's performance was effortful and accurate of their true cognitive abilities (Meyers & Meyers, 1995; Lu et al., 2003; Rai et al., 2019). Effort on the RCFT is determined by calculating the number of accurately identified target figures on the copy and recognition trials as well as penalizing an individual for endorsing any of the foils (Lu et al., 2003; Rai et al., 2019; Reedy et al., 2013).

Patients presenting for neuropsychological evaluations most commonly complain of memory impairment as the primary cognitive issue they are experiencing (Capruso & Levin, 1992; Schwarz et al., 2009). For most healthy individuals with normal cognitive functioning their reduction in memory capabilities is generally associated with increasing age, and predominantly this deficit is seen in their ability to acquire as well as recall new information (Fjell et al., 2005; Small et al., 1999; Tombaugh & Hubley, 2001; Trahan & Larrabee, 1992). Research indicates that successful retrieval of information from memory depends on the interaction between several brain regions involving the frontal and medial temporal lobe structures, specifically the prefrontal cortex and hippocampus (Dubois et al., 2007; Hayes et al., 2004; Kohler et al., 1998; Mecklinger & Meinshausen, 1998; Nemmi et al., 2013; Persson er al., 2013; Zammit et al., 2017). Additionally, to compensate for age-related decline adults often tend to rely more on their prefrontal cortex during encoding and retrieval processes when trying to access information from memory (Davis et al., 2008: Hampstead et al., 2016; Lieu et al., 2013; Moscovitch et al., 2005; Zammit et al., 2017).

The RCFT has proven to be a useful measure for assessing visual memory recall in various neurocognitive disorders for both children and adults, yet for the older adult population

recall performance often exhibits some decline over time rather than improvement (Fastenau et al., 1999; Yamashita, 2015). Older adults have shown the ability to perform comparable to younger individuals on the initial copy phase of the RCFT, yet they often produce significantly worse scores on the long delay recall trials. However, there is evidence that the use of additional recall trials can help prevent memory decay over time (Loring et al., 1990; Meyers & Meyers 1995; Mitrushina & Satz, 1989; Tombaugh & Hubley, 2001; Trahan & Larrabee, 1992; Yamashita, 2015; Youngjohn & Crook, 1993). Age-related decline can negatively impact the acquisition of new visual information leading to continued difficulties in memory performance (Loring et al., 1990; Meyers & Meyers 1995; Yamashita, 2015). While various administration procedures are utilized, further research is necessary on whether the timing of the delay period and introduction of subsequent recall trials (e.g., free recall, recognition) has a significant impact on memory performance in older adults (Meyers & Meyers, 1995; Strauss et al., 2006; Yamashita, 2015).

Purpose of the Study

The purpose of this study is to look at the clinical utility of a short-form version of the Rey Complex Figure Test (RCFT) as part of a neuropsychological battery for testing visual memory in an older adult population with suspected neurocognitive impairments. The short-form will consist of a similar administration procedure as the standard form including an initial copy phase, an immediate recall trial, a delayed recall trial, and followed by a recognition trial. While the short-form will administer the same number of the trials, the period between the immediate and delayed recall portions of the measure will be reduced from 30 to 10 minutes. For older individuals, visual memory can often be difficult to assess in a neuropsychological battery due to the challenging task of differentiating early memory problems and impairments from normal

cognitive aging or other psychosocial factors, particularly anxiety. Thus, the primary objective will be to establish the clinical utility for a short-form version of the RCFT that is accurate at capturing visual deficits in the older adult population in a more brief and cost-effective manner.

Hypotheses

Research Question I

Does a short-form version of the Rey Complex Figure Test (RCFT-SF) accurately identify memory impairments in an older adult population when compared to the standard administration RCFT?

Hypothesis I

The RCFT-SF will identify cognitive impairments in visual memory particularly visuospatial recall, visuospatial recognition, response bias, processing speed, and visuospatial constructional ability equivalent to the standard administration procedures indicated by scores across the copy, recall (immediate/delayed), and recognition trials.

Research Question II

Do higher levels of state and trait anxiety as measured by the State-Trait Anxiety Inventory (STAI), interfere with the ability to recall and recognize visual information as indicated by lower scores on the recall (immediate/delayed) and recognition trials from the RCFT-SF?

Hypothesis II

Higher levels of state and trait anxiety on the STAI will be negatively associated with performance on the RCFT-SF leading to lower scores for visuospatial recall on the immediate and delayed recall trials and inaccurate recognition of the figure's identifiable parts.

Research Question III

Does the shortened administration time between the delayed recall and recognition trials on the RCFT-SF benefit older adults with different levels of cognitive impairment?

Hypothesis III

Older adults with mild levels of cognitive impairment will have higher scores on the recall and recognition trials of the RCFT-SF, while those with moderate-severe levels of cognitive impairment will have low scores on the recall and recognition trials for the RCFT-SF.

CHAPTER 2: REVIEW OF THE LITERATURE

As life expectancy has steadily increased overtime, the older adult population continues to grow and is predicted to double from 43 million in 2012 to 84 million by 2050 (Kramer et al., 2020; Ortman et al., 2014). One of the strongest risk-factors associated with developing cognitive impairments and functional decline is aging, with the incidence rate doubling every 5 years after the age 65 (Jorm & Jolley, 1998; Kramer et al., 2020). In the United States alone, the current estimated cost for the care of individuals with some form of dementia is $215 billion per year and the amount is predicted to double by the year 2040 (Hurd et al., 2013; Kramer et al., 2020). Findings from a national study showed that approximately 14% of older adults aged 70 and older had some form of dementia, while between 10 to 15% of older adults in primary care settings exhibited some signs of cognitive impairment (Callahan et al., 1995; Holsinger et al., 2012; Lopez et al., 2003; Plassman et al., 2007). Additionally, the prevalence of mild cognitive impairment (MCI), which is characterized as cognitive decline that is slightly more pronounced than typical normal aging, amongst older adults has been reported to be around 6.9% to 22% (Holsinger et al., 2012; Lopez et al., 2003; Lyketsos et al., 2005; Monastero et al., 2007; Overton et al., 2019; Plassman et al., 2008). Individuals diagnosed with a cognitive impairment have also been shown to develop dementia at a greater rate than those with normal cognitive profiles, with about 12% of cases per year (Holsinger et al., 2012; Overton et al., 2019; Plassman et al., 2008). As the number of older adults across the world gradually expands, there is a rising need for neuropsychological instruments that are sufficiently sensitive for detecting significant cognitive changes and impairments in order to enhance treatment care for the aging population (Kramer et al., 2020).

Role of Assessment

For individuals reporting a decline in their cognitive functioning, neuropsychological assessments play a vital role in helping to identify the level of impairment, detecting behavioral changes, and assessing for functional disabilities (Battista et al., 2017). Neuropsychological evaluations help to quantify an individual's cognitive and behavioral functioning and provide information that can be essential for the diagnosis and treatment of neurocognitive disorders (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011). Comprehensive assessments primarily include measures that focus on examining sensory, motor, and perceptual functioning in order to better understand the impact deficits have on an individual's cognition (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011). The data obtained from a patient on the various tests during the neuropsychological evaluation are compared to a set of scores from similar patients on the same measures (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011). The normative scores compiled for each individual test within a battery is important for allowing a relative comparison amongst the population to help detect any impairments in the patient's cognitive functioning (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011). As a result, the pattern of neuropsychological deficits associated with particular brain functions that emerge help provide the appropriate recommendations based on the individual's needs and guide treatment (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011).

A formal neuropsychological assessment may either be brief or extensive and is often dependent on several factors, such as the primary referral problem (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013). Both types of evaluations focus on use of standardized measures for the assessment of higher level cognitive processing

including attention, concentration, reasoning, problem solving, language, memory, and visuospatial skills (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013). The main objective is to collect data in order to identify the presence of any significant deficits within these cognitive areas. Patient scores from each test administered are matched as closely as possible to demographic factors (i.e., age, education, gender, ethnicity, etc.) from that specific measure's normative sample to help provide appropriate comparisons and detect levels of cognitive impairments (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013). While both formats adhere to the same administration procedures, brief evaluations offer several benefits over longer batteries. These often include quicker administration time for the neuropsychological measures, repeatability, shorter period between testing intervals, and the ability to target specific deficits (Casaletto & Heaton, 2017; Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013).

Patients presenting for neuropsychological evaluations most commonly complain of memory impairment as the main cognitive issue they are experiencing (Capruso & Levin, 1992; Schwarz et al., 2009). For most healthy individuals with normal cognitive functioning, their reduced memory capabilities are generally associated with increasing age. These deficits are evident in both their ability to acquire and recall new information (Fjell et al., 2005; Small et al., 1999; Tombaugh & Hubley, 2001; Trahan & Larrabee, 1992). Functional neuroimaging has shown there is a significant interaction amongst several brain regions that are linked to successful encoding and retrieval of information from memory (Davis et al., 2008: Hampstead et al., 2016; Lieu et al., 2013; Moscovitch et al., 2005; Nyberg et al., 2000; Roediger et al., 2002; Spaniol et al., 2009; Wheeler et al., 2000). Structures located in the medial temporal lobe, specifically the hippocampus, play an essential role in memory and research has suggested that

different areas within these cortical regions are activated for verbal and spatial abilities (Dubois, et al., 2007; Hayes et al., 2004; Kohler et al., 1998; Mecklinger & Meinshausen, 1998; Nemmi et al., 2013; Persson et al., 2013; Zammit, 2017). For example, the cortical area within the right part of the hippocampus has been strongly associated with spatial memory, while the cortical region of the left hippocampus has been connected more to verbal memory processes (Dubois, et al., 2007; Hayes et al., 2004; Kohler et al., 1998; Mecklinger & Meinshausen, 1998; Nemmi et al., 2013; Persson et al., 2013; Zammit, 2017). Adults also tend to rely more on their prefrontal cortex during encoding and retrieval processes in order to compensate for age-related decline (Davis et al., 2008: Hampstead et al., 2016; Lieu et al., 2013; Moscovitch et al., 2005).

Neuropsychologists are often given the challenging task of differentiating early memory problems and impairments from merely typical struggles associated with normal cognitive aging as well as those caused by psychosocial factors, such as anxiety (Dorenkamp & Vik, 2018; Kramer et al., 2020; Mutchnick & Williams, 2012). In order to detect any possible functional changes or impairment associated with cognition, neuropsychologists rely on normative data compiled from the various measures utilized in the assessment battery to compare the performance of one individual to that of their normal and healthy age-related peers (Kramer et al., 2020; Negash et al., 2011). Thus, it is important for individuals represented in the normative sample to have scores consistent with typical and healthy cognitive aging allowing for neuropsychologists to appropriately derive accurate estimates of impaired performances on testing (Kramer et al., 2020; Negash et al., 2011). As the older adult population increases, it is important for neuropsychological assessments to continue to evolve and meet the needs of this growing population (Vacha-Haase, 2013). Neuropsychological evaluations have the capability to improve the quality of treatment care for older adults, and as a result the continued use and

development of standardized as well as evidenced-based assessment practices will be essential for providing appropriate services to the older adult population (Hunsley & Mash, 2007; Knight, 2004; Vacha-Haase, 2013). Thus, it is important to consider a multitude of factors, including the length of the overall battery and test administration, when determining the appropriate measures to use for assessing cognitive impairments for older adults.

Meyers Neuropsychological Battery (MNB)

The Meyers Neuropsychological Battery (MNB) is a comprehensive testing system comprised of frequently used neuropsychological measures organized to evaluate distinct cognitive domains both independently and collectively. The eight primary domains assessed include attention and concentration, processing speed, verbal reasoning, visual reasoning, verbal memory, visual memory, dominant motor and sensory, and nondominant motor and sensory (Meyers, 2003; Meyers et al., 2014; Meyers & Rohling, 2004; Meyers et al., 2011). The overall test battery mean (OTBM) is used to measure an individual's general performance and is comprised of the overall mean of test scores obtained from all of the administered measures in the MNB (Miller & Rohling, 2001; Meyers, 2003; Meyers et al., 2014; Meyers & Rohling, 2004; Rohling et al., 2003). In order to detect a level of impairment, the OTBM is compared with an individual's estimated premorbid functioning which is determined based on demographic information (e.g., age, gender, education level, and region) and performance on the North American Adult Reading Test (NAART). Additionally, the MNB utilizes several embedded performance validity measures to evaluate adequate performance and sustained effort (Meyers, 2003; Meyers et al., 2011; Meyers & Volbrecht, 2003; Meyers et al., 2011).

After completing a comprehensive evaluation, the MNB often employs a pattern analysis to match an individual's data to those of various comparison groups in order to assist in the

interpretation of the test scores and determine a potential diagnosis (Lezak et al., 2004; Meyers, 2003; Meyers et al., 2014; Meyers & Rohling, 2004). This is often done visually in the form of a line graph, which allows for the emergence of consistent patterns within the data set in an easy and straightforward manner relative to the typical summary table created for the same scores. One specific pattern discovered in the MNB important for interpretation is found in the attention and concentration domain known as the mountains and valleys pattern (MVP), which refers to the wide variability in performance seen across an individual's test scores (Meyers, 2003; Meyers et al., 2014). The MVP is an important diagnostic indicator because it suggests the patient's performance may have potentially been impacted by significant interference from emotional distress, such as anxiety, leading to the considerable variations in their scores (Meyers et al., 2014). The MVP captures the individual's reaction to stress and worry, which may be influenced by situational or state anxiety regarding the evaluation and is contributing to their poor performance. Ultimately, the MVP helps to demonstrate the significant impact of emotional distress and the negative effects of anxiety on cognitive performance in the MNB (Meyers et al., 2014).

Memory & Learning

The ability to effectively facilitate an experience into a memory involves a series of multifaceted procedures that rely on the integrity of several brain functions to operate. Memory refers to the complex process by which an individual encodes, stores, and retrieves information (Kolb & Whishaw, 2015; Schoenberg & Scott, 2011). Donald Hebb (1949) posited there was no single mechanism that accounted for how an individual is able to learn and retain information. Thus, he proposed a difference between short-term memory for events that just occurred and long-term memory for events that happened further back (Hebb 1949; Kalat, 2017).

Short-term memory and long-term memory differ in their operating capacities and methods of storage (Kalat, 2017). For example, if an individual is presented with a series of unrelated numbers or letters, they will most likely be able to repeat no more than approximately seven of them before their ability to hold onto that information diminishes. However, the capacity to hold onto large amounts of data within long-term memory is considerable (Kalat, 2017). Short-term memory depends on rehearsal to achieve adequate storage, while long-term memory can be reconstructed or recalled without the need to be consistently repeated (Kalat, 2017; Peterson & Peterson, 1959). Finally, once an individual forgets or is unable to remember something it is lost in short-term memory. Conversely, recognition is often helpful in long-term memory by allowing an individual to recall and reconstruct information they once believed to be completely forgotten (Kalat, 2017).

Encoding is associated with the processing of information within short-term memory that can then be stored into long-term memory by means of consolidation (Banich, 2004; Heuer & Rolfs, 2021; Kolb & Whishaw, 2015; Schoenberg & Scott, 2011; Strauss et al., 2006). This notion was initially posited by Hebb (1949), who theorized storing information in short-term memory for a sufficient period of time allows the brain to build new synapses and create other structural changes that consolidates the newly gained information into long-term memory (Hebb 1949; Kalat, 2017). The result of acquiring and consolidating information allows an individual to create and then maintain a permanent memory trace, which strengthens the newly learned information and forms it into mental representations for later retrieval (Banich, 2004; Kolb & Whishaw, 2015; Schoenberg & Scott, 2011; Strauss et al., 2006).

The process by which information is transferred from encoding to storage often varies on the type of the material that is needed to be recalled. Studies examining memory in both a normal

healthy population and patients with amnesia have evidenced that memory is often not a single process (Moscovitch, 2004; Schoenberg & Scott, 2011; Strauss et al., 2006). Rather it consists of a several forms, which are all mediated by distinctive component processes and further promoted by various neural mechanisms (Moscovitch, 2004; Schoenberg & Scott, 2011; Strauss et al., 2006). As a result, there are basic memory stages: sensory storage, short-term memory, and long-term memory. Sensory storage refers to the point of time where auditory, visual, gustatory, tactile, or olfactory information is registered by an individual's consciousness (Kolb & Whishaw, 2015; Schoenberg & Scott, 2011; Strauss et al., 2006). This memory process is extremely short in duration (several milliseconds) and decays rapidly, thus requiring an individual to attend to the information in order to transfer it to short-term memory (Kolb & Whishaw, 2015; Schoenberg & Scott, 2011; Strauss et al., 2006). For short-term memory processes such as organizing and rehearsal are needed to store information, while long-term memory occurs once it is consolidated. These phases of memory associated with short-term and long-term storage can be further broken-down into various types including explicit, implicit, episodic, semantic, procedural, auditory/verbal, and visuospatial (Kolb & Whishaw, 2015; Schoenberg & Scott, 2011; Squire & Zola, 1996; Strauss et al., 2006).

Short-Term (Working) Memory

Short-term memory, also known as working memory, is primarily used to record and hold onto recent sensory events, movements, and cognitive information as well as the order in which they happened (Allen et al., 2014; Kolb & Whishaw, 2015; Teixeira-Santos et al., 2019; Warrington & Weiskrantz, 1978). Working memory is considered to only consist of limited capacity storage that retains information over a short amount of time and also allows an individual to perform mental operations on its contents (Kolb & Whishaw, 2015; Lezak et al.,

2012; Schoenberg & Scott, 2011; Strauss et al,, 2006; Teixeira-Santos et al., 2019). The information found in working memory can begin either from sensory inputs or can be retrieved from long-term storage. As a result, working memory contains information that an individual can act on and process. It also helps guide behavior in the absence of external cues. Working memory also ensures that information will be available until the individual can effectively encode and store it into long-term memory (Gazzaniga et al., 2002; Kolb & Whishaw, 2015; Lezak et al., 2012; Schoenberg & Scott, 2011; Strauss et al., 2006; Teixeira-Santos et al., 2019).

One of the primary ways working memory is distinguished from long-term storage can be seen in amnestic patients who are able to demonstrate normal performances on a digit span forward task, which requires them to repeat aloud a series of non-related numbers, and a task requiring them to repeat a series of digits in reverse order (Moscovitch, 2004; Schoenberg & Scott, 2011; Strauss et al.; Wilde et al., 2004). Despite the ability to perform adequately on these kinds of short-term memory tasks, amnestic patients often show significant impairments in being able to retain and recall material after experiencing a short time interval between the initial presentation of information and given a distractor task (Moscovitch, 2004; Schoenberg & Scott, 2011; Strauss et al., 2006; Wilde et al., 2004). For example, patients given a list-learning task tend to have difficulties when asked to recall the initial set of words after a brief period and given another task (e.g., another set of words, counting backwards) in between (Moscovitch, 2004; Schoenberg & Scott, 2011; Strauss et al., 2006; Wilde et al., 2004). Research has shown that working memory is an important part of learning, and without some process of organizing or rehearsing information found in working memory, it will not be consolidated and can be quickly forgotten (Kyllonen, 1987; Kyllonen & Christal, 1990: Schoenberg & Scott, 2011; Strauss et al., 2006).

Long-Term Memory

Long-term memory refers to information that is relatively permanent and can be willingly retrieved by the individual. There are several processes that help to facilitate the consolidation and transfer of information into long-term memory, including rehearsal (Kolb & Whishaw, 2015; Tulving & Schacter, 1990; Schater & Tulving, 1994; Schoenberg & Scott, 2011; Spaan et al., 2004; Squire & Bayley, 2007; Strauss et al., 2006). Information that is often associated with an emotional experience, either positive or negative, is also more readily encoded and enables retrieval (Kolb & Whishaw, 2015; Lezak et al., 2012; Schoenberg & Scott, 2011). Additionally, encoding into long-term memory and subsequent retrieval is often more efficient when information is made more salient, relatable, further developed by the individual, and associated with previously learned material. For example, individuals are able to retrieve more words when asked to describe themselves using the different terms compared to being asked if the word has a positive or negative connotation (Kolb & Whishaw, 2015; Lezak et al., 2012; Schoenberg & Scott, 2011).

Visual Short-Term and Working Memory

Visual short-term memory, also known as visual working memory (VWM), is an essential component of everyday cognition and typically begins to deteriorate starting around 21 years of age, with the ability to hold onto larger and more complex pieces of information halving by the age of 75 (Brockmole & Logie, 2013; Heuer & Rolfs, 2021; Mitchell & Cusack, 2018). VWM involves the brief and limited capacity to retain visual information in the absence of visual stimuli (Brockmole & Logie, 2013; Heuer & Rolfs, 2021; Ko et al., 2014; Mitchell & Cusack, 2018). Consequently, as adults age the capacity for several items to be held in the mind over a brief period of time and the number that can be remembered, as well as the precision with which

each is remembered, significantly reduces (Mitchell & Cusack, 2018; Noack et al., 2012; Peich et al., 2013; Pertzov et al., 2015). Often this increases in association errors, in which the features (e.g., location and color) of two different items are erroneously related to each other, resulting in deficits with associative memory (Cowan et al., 2006; Mitchell & Cusack, 2018; Mitchell et al., 2000; Naveh- Benjamin, 2000; Peich et al., 2013; Pertzov et al., 2015).

During the process of VWM, cells within the prefrontal cortex have demonstrated the ability to synchronize activity and work together with cells from other cortical areas (Kalat, 2017; Liebe et al., 2012; Salazar et al., 2012). For example, performance on a delayed visual response task where an individual is asked to stare at central point and then locate where they saw a flashing light on the screen following an auditory cue, shows increased activity among certain cells in the prefrontal and parietal cortices (Chafee & Goldman-Rakic, 1998; Kalat, 2017). Many older adults tend to have impairments in working memory, which can be associated with changes in the prefrontal cortex (Kalat, 2017; Rosen et al., 2002; Rossie et al., 2004; Smith et al., 2004). Research indicates that older individuals with a decline in memory functions often show decreased activity in the prefrontal cortex, while those whose memory is more intact show greater activity than young adults (Kalat, 2017; Rosen et al., 2002; Rossie et al., 2004). This increased neuronal activity potentially suggests that older individuals are attempting to compensate for impairments occurring in other locations in the brain by increasing activity in the prefrontal cortex (Chafee & Goldman-Rakic, 1998; Kalat, 2017; Rosen et al., 2002; Rossie et al., 2004).

Age-Associated Factors

An abundance of research has been dedicated to understanding the possible factors that limit the capacity of VWM (Bays & Husain, 2008; Cowan, 2001; Ko et al., 2014; Mitchell &

Cusack, 2018; Vogel et al., 2005; Woodman et al., 2003; Zhang & Luck, 2008). Consistently throughout the literature, the process of aging in healthy individuals has been revealed to significantly reduce VWM abilities (Brockmole et al., 2008; Brown & Brockmole, 2010; Cowan et al., 2006; Ko et al., 2014; Mitchell & Cusack, 2018; Reuter- Lorenz & Sylvester, 2005; Vaughan & Hartman, 2009). Additionally, age-related declines in VWM performance have been found to include deficits in the encoding of various features (e.g., color/ orientation/location) and time durations (e.g., 200 ms to 2,000 ms; Hoefeijzers et al., 2017; Ko et al., 2014; Mitchell & Cusack, 2018). However, the particular aspects of VWM that decrease over the course of normal aging is unclear. Thus, examining how age impacts the multiple stages of VWM may help to better understand this problem (Brockmole, et al., 2008; Hoefeijzers et al., 2017; Ko et al., 2014; Mitchell & Cusack, 2018; Parra et al., 2009).

Information Binding

The difficulty of how aging affects cognition and VWM has also been investigated in the context of memory deficits for learning new information and the capacity to retrieve previously learned information. Older adults tend to have impairments in their ability to associate distinct and separate pieces of information in order to connect them together into a singular, cohesive unit and form complex memories (Ko et al., 2014; Mitchell & Cusack, 2018; Naveh-Benjamin, 2000). For example, older adults find it hard to create and retrieve links between single basic units of information (e.g., semantic content, physical characteristics, time/place of an event, etc.) for more successful encoding and consolidation (Ko et al., 2014; Naveh-Benjamin, 2000). This skill is a critical component at play during the encoding process of information in VWM (Ko et al., 2014; Wheeler & Treisman, 2002). Studies examining how older adults relate visual features in VWM during encoding have reported mixed results, with some studies revealing an

impairment in the ability to bind separate information (Brown & Brockmole, 2010; Cowan et al., 2006), and others showing intact abilities to connect distinct visual information together (Brockmole et al., 2008; Parra et al., 2009).

Inhibition Abilities

Studies on event-related potential (ERP) have more consistently supported the theory that older adults have a reduced ability to inhibit irrelevant information (Hasher & Zacks, 1988; Ko et al., 2014; Mitchell & Cusack, 2018). For example, Gazzaley and colleagues (2008) found that older adults exhibited delayed inhibition of task-irrelevant information, relative to younger adults, during the encoding process in VWM. Another study by Jost, Bryck, Vogel, and Mayr (2011) used an ERP measure identified as contralateral delay activity (CDA) to estimate VWM abilities. Results found age-related differences in the participants' ability to filter out task-irrelevant information that was encoded into their VWM. Both ERP studies suggest that inhibitory processes during VWM encoding are significantly delayed, but not eliminated, during the course of healthy aging (Ko et al., 2014; Mitchell & Cusack, 2018).

Task Information Manipulation

Age also impacts VWM by causing a significant reduction in the number of items that an individual can encode and store (Bopp & Verhaeghen, 2009; Forsberg et al., 2019; Sander et al., 2011). VWM is believed to support effective operations of other cognitive functions. These include perception, problem-solving, general intelligence, and overall reasoning ability (Conway et al., 2003; Forsberg et al., 2019; Kyllonen & Christal, 1990; Ma et al., 2014; Unsworth et al., 2014). As a result, age-related cognitive decline in VWM can significantly impact an individual's ability to retain visual information and accurately recall features of stimuli (Bowles & Salthouse, 2003; Forsberg et al., 2019; Gazzaley et al., 2005; Johnson et al., 2010).

Recognition Memory

While memory loss is one of the most frequent cognitive complaints and is typically associated with aging, evidence suggests that not all aspects of memory demonstrate the same rate or degree of age-related cognitive decline (Burke & Mackay, 1997; Graves et al., 2018; Starkstein & Kremer, 2001; Wegesin et al., 2000). Several studies have indicated that the impact of aging is often more prevalent on source memory, which refers to the context from which information is learned or acquired, than on item memory, which relates to the content of information regardless of its source (Bayer et al., 2011; Dennis et al., 2008; Fraundorf et al., 2019; Glisky & Kong, 2008; Hashtroudi et al., 1989; McIntyre & Craik, 1987; Naveh-Benjamin & Craik, 1995; Schacter et al., 1991; Spaniol et al., 2006; Trott et al., 1999). Specifically, item memory refers to the ability for an individual to remember details of what happened, while source memory denotes the ability to remember where, when, and how something occurred (Dennis et al., 2008; Graves et al., 2018).

On tasks associated with assessing different aspects of memory (i.e., source vs item), impaired encoding of contextual information has led to poor performance in older adults (Graves et al., 2018; Johnson et al., 1993). Thus, age-related cognitive decline may be a result of the inability to integrate contextual information during the encoding process and making it difficult to recall (Graves et al., 2018). Older adults may only possess limited cognitive resources for encoding stimuli and may be unable to incorporate contextual information at the same time, resulting in poorer recall (Glisky & Kong, 2008; Graves et al., 2018; Johnson et al., 1993).

Recognition memory is a component within the memory process that involves the ability to recognize previously encountered stimuli. While recognition memory has been shown to decline with age, it is often not as significantly impacted to the same extent as recall (Craik &

McDowd, 1987; Danckert & Craik, 2013; Graves et al., 2018). For example, the second edition of the California Verbal Learning Test (CVLT-II) is a widely used verbal measure in both research and clinical settings to assess memory function and decline in numerous populations including older adults (Delis et al., 2000). Results in general show that older adults often display significantly worse performances relative to younger adults on indices related to the recall of information, yet only have marginally lower performances on the recognition tasks (Delis et al., 1987; Delis et al., 2000; Ebert & Anderson, 2009; Kausler, 1994; Turner & Pinkston, 1993; Van der Linden et al., 1997; Woodruff-Pak & Finkbiner, 1995).

Retrieving Effectively from Memory Model

Shiffrin and Stevvers (1997) developed the retrieving effectively from memory (REM) model that accounts for how successful an individual is at retrieving and recognizing information (Sahakyan, 2019). REM distinguishes between two types of information stored in memory: one based on contextual details and one that is constructed from item features (Sahakyan, 2019; Shiffrin & Stevyers, 1997). In free recall, context plays an important role because contextual cues are the only information available to initiate the search process and retrieve information from memory (Sahakyan, 2019; Shiffrin & Stevyers, 1997). On the other hand, recognition is more dependent on identifying and matching the information stored memory (Sahakyan, 2019; Shiffrin & Stevyers, 1997). REM posits that older adults may store less contextual details throughout the encoding process, making their mental representations more generic and limiting their ability to recall information accurately (Sahakyan, 2019; Shiffrin & Stevyers, 1997). Notably, despite potential cognitive declines in other domains older adults seem to have a stronger ability for storing larger number of item details or types of features leading to better recognition memory (Sahakyan, 2019; Shiffrin & Stevyers, 1997).

Age Associated Memory Impairment

Age-associated memory impairment (AAMI) refers to the relative decline in memory for and otherwise healthy older individual that is negatively impacting their daily functioning (Crook et al., 1986; Larrabee & Crook, 1994; Ratcliff et al., 2003; Ratcliff & Saxton, 1994; Starkstein & Kremer, 2001). Older adults experiencing memory problems tend to also have impairments in other cognitive domains including language, attention, concentration, and visuospatial functioning (Crook et al., 1986; Larrabee & Crook, 1994; Ratcliff et al., 2003; Ratcliff & Saxton, 1994; Starkstein & Kremer, 2001).

Age-related Structural Changes

As the brain develops throughout the lifespan it experiences significant structural changes (Lockhart & DeCarli, 2014; Oschwald et al., 2020). Neuroimaging studies looking at the impact of aging on the brain have showed that advancing age is generally associated with decreased brain tissue size, particularly significant reductions in gray and white matter volumes in several regions, and increased volume of cerebrospinal fluid (CSF; Coffey, 2000; Coffey et al., 2001; Hedman et al., 2012; Oschwald et al., 2020; Stein et al., 2012). Cognitively, aging may be characterized as a general slowing of cognitive functioning. There is evidence of a relationship between age-related cognitive declines, cortical volume changes, and increased CSF space amongst older individuals (Coffey, 2000; Coffey et al., 2001; Stein et al., 2012). In a study by Coffey and colleagues (2012), results from a large sample of 320 elderly individuals found that increased age was associated with diffuse cerebral atrophy and increased size of the ventricles. Additionally, the older participants exhibited a decreased performance on tests of attention, psychomotor speed, memory, and visuospatial construction (Coffey et al., 2001).

The volume of gray matter in the brain gradually reduces across the lifespan and typically follows a last-in-first-out pattern (Hedman et al., 2012; Oschwald et al., 2020; Sowell et al., 2004). Anterior brain regions, such as the prefrontal cortex, are often the first areas to show age-related decline in functioning since they are ordinarily the last to mature in development. Meanwhile, posterior regions including the visual and auditory cortices seem to be less vulnerable to atrophy since these areas mature and develop earlier on (Hedman et al., 2012; Oschwald et al., 2020; Sowell et al., 2004; Ziegler et al., 2012). Additionally, structures located in the medial temporal regions including the hippocampus and amygdala show moderate signs of reduction in functioning across various age groups with the highest levels of decline evident in older adults (Tamnes et al., 2013; Oschwald et al., 2020).

While research has suggested white matter has the potential to continue developing up to around the age of 50, it is then followed by a period of accelerated decline as age increases (Hedman et al., 2012; Liu et al., 2016; Oschwald et al., 2020; Westlye et al., 2010). The largest age-related declines in white matter appear in the frontal, temporal, and parietal regions, whereas the areas in the occipital cortex appear to remain relatively spared from significant atrophy due to aging (Bartzokis et al., 2001; Oschwald et al., 2020; Raz et al., 2005; Resnick et al., 2003). Additionally, the accumulation of white matter hyperintensities (WMH) in older adults are often linked to changes in vascular functions due to aging and have been associated with cognitive deficits in memory processes (Bennett & Madden, 2014; Debette & Markus, 2010; de Leeuw et al., 2001; Oschwald et al., 2020; Prins & Scheltens, 2015; van Leijsen et al., 2018; Wardlaw et al., 2013). Furthermore, several neuroimaging studies of older adults have indicated there is an association between WMH and hippocampal atrophy that leads to poor cognitive performance and memory decline (de Leeuw et al., 2004; den Heijer et al., 2012; Eckerstrom et al., 2011;

Fiford et al., 2017; Godin et al., 2010; Prins & Scheltens, 2015; van der Flier et al., 2005; van Leijsen et al., 2019; Ye et al., 2015). Evidence also suggests that WMH may directly impact cognition due in part to the disconnection amid the various cortical and subcortical regions generated by the demyelination and gliosis of the neural tracts (Inzitari et al., 2000; Oschwald et al., 2020).

In older adults the volume of CSF in the brain is estimated to be much larger compared to younger adults. The ventricles containing the CSF often appear to expand throughout the aging process, with the increase in size remaining minimal and relatively stable up to middle adulthood with a period of exponential growth occurring afterwards (DeCarli et al., 2005; Carmichael et al., 2007; Fjell et al., 2013; Oschwald et al., 2020). The enlargement of the ventricles in the brain has also been associated with diffuse structural changes and can often be used as an indicator for the progression of neurodegenerative disorders (Madsen et al., 2013: Oschwald et al., 2020).

The ability to remember the specific details regarding the context and content of a particular situation or item may be associated with different brain regions (Graves et al., 2018). Neuroimaging of patients with focal brain lesions have shown evidence that both the frontal and temporal lobes are important structures correlated with memory functions (Awipi & Davachi, 2008; Cansino et al., 2002; Ekstrom & Bookheimer, 2007; Graves et al., 2018; Janowsky et al., 1989; Kirwan et al., 2008; Mitchell et al., 2006; Peters et al., 2007; Peters et al., 2007). Consequently, this suggests that age-related decline within the frontal and temporal regions may account for memory impairments often seen in normal aging (Dennis et al., 2008; Fan et al., 2003; Glisky & Kong, 2008; Glisky et al., 2001; Graves et al., 2018; Henkel et al., 1998; Mitchell et al., 2006). Results from a study by Reuter-Lorenz and colleagues (2000) using positron emission topography (PET) scans to identify age-related differences in verbal and

spatial working memory found significant differences in neuronal activation for brain components associated with working memory abilities between older and younger adults. Notably, older adults showed bilateral activation in both frontal and anterior brain regions, whereas younger adults demonstrated lateralization effects in frontal and anterior regions with greater activation in the left-hemisphere for verbal information and greater right-hemisphere activation for spatial information (Reuter-Lorenz et al., 2000; Reuter-Lorenz et al., 1999). These findings suggest that older adults have increased difficulties accessing working memory abilities and require greater mental effort due to the decreased efficiency of neuronal substrates, particularly within the frontal region, as a result of increased vulnerability from normal aging. Consequently, they require the use of activation from not only the frontal regions from both the left and right hemispheres but also from additional anterior components in order to compensate for their increased difficulties and adequately function or perform daily tasks (Reuter-Lorenz et al., 2000; Reuter-Lorenz et al., 1999).

While reductions in total cortical volume have been related to aging, there is also evidence for age-related decrease in cortical volume for specific brain structures such as the basal ganglia, prefrontal cortex, and the hippocampus (Gunning-Dixon et al., 1998; Meyer et al., 1994; Starkstein & Kremer, 2001; van Leijsen et al., 2019). In an analysis of volumetric brain measurements for older adults over a 5-year period, findings revealed a significant correlation between age and decreased total cortical volume including areas within the frontal and temporal lobes as well as the hippocampus and parahippocampal regions (Mueller et al., 1998; Starkstein & Kremer, 2001; van Leijsen et al., 2019; Zammitt et al., 2017). Additionally, smaller frontal lobes have been significantly correlated with older age and increased deficits in executive functioning including attention, perceptual reasoning abilities, cognitive flexibility, and working

memory (Raz et al., 1997; Schretlen et al., 2000; Starkstein & Kremer, 2001; Oschwald et al., 2020).

Memory & Learning

In older individuals, certain memory processes such as autobiographical memory, procedural learning, and some aspects of semantic knowledge are often relatively better preserved than those that require new associations and the use of encoding strategies (Burke & Mackay, 1997; Starkstein & Kremer, 2001; Wegesin et al., 2000). When recalling an event, memory abilities that often decline with age include the ability to retrieve contextual information and identify recently presented stimuli (Craik et al., 1990; Parkin et al., 1995; Starkstein & Kremer, 2001). In a study conducted by Fabiani and Friedman (1997) examining memory recall results showed an age-related decline for both verbal and visual stimuli, yet recognition memory was intact for visual information. These results indicated older individuals had difficulties recalling information, yet when provided cues were able to recognize visual information (Fabiani & Friedman, 1997; Starkstein & Kremer, 2001).

Age-related declines have also been found in working memory, processing speed, and associative learning (Kirasic et al., 1996; Starkstein & Kremer, 2001). The elderly population also shows increased deficits on a visual memory tests, with particular difficulties encoding and recalling spatial locations and recalling complex geometrical designs (Adamowicz & Hudson, 1978; Fahle & Daum, 1997; Light & Zelinski, 1983; Starkstein & Kremer, 2001). Finally, another area associated with age-related decline involves visuospatial cognition specifically that older adults often show greater impairments for tasks as associated with visuospatial processing and working memory (Jenkins et al., 2000; Starkstein & Kremer, 2001).

Visuospatial Abilities

There are a range of cognitive tests that assess visuospatial skills which primarily include the domains of visual discrimination, recognition, attention, spatial memory, and planning (Starkstein & Kremer, 2001). Older adults typically perform considerably worse on tasks assessing facial discrimination and judgment of line orientation, suggesting that the age-related decline in spatial abilities may be primarily related to the specific visual, perceptual, and memory demands of the task (Eslinger & Benton, 1983; Ogden, 1990; Starkstein & Kremer, 2001). Age-related cognitive decline is evident across several domains including memory, visuospatial skills, and other executive functions (e.g., set shifting, problem solving; Starkstein & Kremer, 2001). Age-associated memory impairments are typically more significant in tasks involving free and cued recall as well as prospective memory (Starkstein & Kremer, 2001). However, amongst older adults the declines tend to be relatively milder for short-term and recognition memory (Starkstein & Kremer, 2001). When attempting to implement a neuropsychological evaluation, it is important to consider these factors and design a battery using measures that will accurately capture deficits in visual memory and visuospatial skills for the older adult population.

Visuospatial & Visuoconstructional Skills

Visuospatial and visuoconstructional skills typically occur automatically without an individual's awareness and play a critical role in processing visual information throughout our daily lives (Schoenberg & Scott, 2011). The brain's visual processing system is often divided into two general tracts originating in the primary visual cortex: one for where stimuli are located in space (dorsal pathway) and another for recognizing objects (ventral pathway; Kolb & Whishaw, 2015; Lezak et al., 2012; Schoenberg & Scott, 2011). These systems are constantly processing visual information and organizing it into usable and salient knowledge (Kolb &

Whishaw, 2015; Lezak et al., 2012; Schoenberg & Scott, 2011). Visuoperception is an integral part of an individual's daily activities and changes in their visuospatial function are typically attributed to several factors including: neurological trauma, degenerative disease, and normal aging (Cubic & Gouvier, 1996; Farley et al., 2011; Royall et al., 2004; Salthouse, 2010; Woodruff-Pak, 1997). For older adults experiencing visuospatial difficulties, the concern is primarily focused on whether impairment is due to normal or pathological changes in brain function and the impact these problems have on their daily functioning (Farley et al., 2011 Royall et al., 2004; Salthouse, 2010; Woodruff-Pak, 1997).

Assessing Visual Memory & Visuospatial Skills

The assessment of memory and visuospatial skills occur in many different settings and across various populations, such as normal healthy individuals or those who have suffered a brain injury (Lezak et al., 2012; Schoenberg & Scott, 2011). Neuropsychological evaluations often approach testing memory with several factors in mind including the length of the battery and the reliability of the scores (Lezak et al., 2012; Schoenberg & Scott, 2011; Strauss et al., 2006). The major components of memory assessed during neuropsychological evaluations includes immediate and delayed recall in addition to recall that is associated with cues and recognition. Assessing these aspects for both verbal and nonverbal information helps provide insight for understanding the role encoding and retrieval have on the process of memory (Lezak et al., 2012; Schoenberg & Scott, 2011; Strauss et al., 2006). When assessing visuospatial skills, the focus is primarily on accuracy to the general shape and overall features to the original design as well as organization and attention to detail to determine potential deficits (Lezak et al., 2012; Schoenberg & Scott, 2011; Strauss et al., 2006). Due to the potential impact age has on various cognitive processes, it is important to consider age-related decline in the areas of visual memory

and visuospatial skills when utilizing tests to accurately measure deficits when conducting neuropsychological evaluations.

Benton Visual Retention Test (BVRT)

The Benton Visual Retention Test is a measure used to assess visual memory, visual perception, and visual-constructive abilities. There are two primary methods of administration for the Benton Visual Retention Test (BVRT) that requires an individual to either draw a series of 10 designs from memory immediately or to choose a design from a series of four choices after a brief exposure (10 seconds). This measure can be used for both children (aged 8-14 years) and adults (aged 15-69 years). Scoring for the drawing administration is comprised of the number of correct reproductions as well as the number of errors the individual produced, while the scoring for the multiple choice option is based on the number of correct choices from a possible 15 (Sivan, 1992; Sivan & Spreen, 1996; Strauss et al. 2006).

The BVRT has been utilized for assessing visual memory since its development in 1946 and has shown to have a number of distinct advantages over other measures (Benton, 1946; Strauss et al., 2006;). These benefits include short administration time, precise scoring criteria, good internal and interrater reliability, and the availability of alternate forms for retesting (Benton, 1946; Sivan, 1992; Sivan & Spreen, 1996; Strauss et al., 2006; Wellman, 1985). Clinical studies with the BVRT have demonstrated some sensitivity to detecting age-related decline, dementia, head injury, and learning disabilities. However, the normative data available for specific age, education level, and ethnic groups varies between the different types of administrations. Also, the specific construct measured by the BVRT has yet to be fully determined due to the whether the measure is more closely assessing visual-perceptual-motor ability rather than visual memory (Sivan, 1992; Sivan & Spreen, 1996; Strauss et al., 2006).

Brief Visuospatial Memory Test-Revised (BVMT-R)

The Brief Visuospatial Memory Test-Revised (BVMT-R) is a measure used to assess visual learning and memory through a multiple-trial list-learning paradigm and was first revised/published in 1996. The BVMT-R requires individuals to learn and retain a series of six visual figures over repeated trials in order to examine the individual's immediate recall of the figures, rate of learning, delayed recall, and recognition (Benedict, 1997; Benedict & Groniger, 1995; Benedict et al., 1996; Strauss et al., 2006). The individual is presented a display of six designs for 10 seconds and then asked to reproduce as many of the designs as possible and in the exact location as they appeared on a blank sheet of paper. The individual has as much time as needed and asked to complete two additional learning trials using the same figures. After a 25-minute delay comprised of multiple distractor tasks, the individual is asked to reproduce the designs again. This is followed by a recognition trial where the individual is presented with 12 designs (6 targets and 6 non-targets) one at a time and asked whether it was one of the figures originally presented (Benedict, 1997; Benedict & Groniger, 1995; Benedict et al., 1996; Strauss et al., 2006).

The BVMT-R can be given to individuals aged 18 to 79 years and the scoring is based on the accuracy and location of the figure (Benedict, 1997; Benedict & Groniger, 1995; Benedict et al., 1996; Strauss et al., 2006). In clinical samples, the BVMT-R has demonstrated good reliability and validity for detecting memory impairments for a variety of neurological conditions including dementia, both Alzhemier's type (AD) and vascular (VaD), HIV infection, multiple sclerosis, and epilepsy (Barr et al., 2004; Benedict, Dobraski, & Goldstein, 1999; Benedict et al., 1996; Strauss et al., 2006). A number of advantages to using the BVMT-R include its relatively short administration time, the availability of six different and equivalent forms to use, and the

inclusion of learning, delayed recall, and recognition trials. However, there are some limitations to the BVMT-R in being able to determine if an individual's poor performance is due exclusively to memory problems or rather visual-constructional and motor deficits. Additionally, since the BVMT-R scoring criteria combines accuracy and spatial location in the normative data, it can be difficult to determine the impact each component has on the diagnostic accuracy for memory impairment (Benedict, 1997; Benedict & Groniger, 1995; Benedict et al., 1996; Strauss et al., 2006).

Bender Visual-Motor Gestalt Test, Second Edition (Bender-Gestalt II)

The Bender Visual-Motor Gestalt Test, Second Edition (Bender-Gestalt II) is one of the most frequently used assessments in neuropsychological evaluations since the first version was developed in 1938 (Bender, 1938; Brannigan & Decker, 2003; Groth-Marnat, 2003). It is designed to measure visual-motor integration skills in children and adults from ages 4 to 85 years old. Administration of the Bender-Gestalt II is comprised of two phases: a copy trial and a recall trial (Bender, 1938; Brannigan & Decker, 2003). During the copy phase, the examinee is shown 16 stimulus cards with different designs and asked to draw each on a blank sheet of paper. In the recall trial, they are asked to redraw the designs from memory (Brannigan & Decker, 2003). While there are no time limits, the evaluator records how long it takes for the examinee to reproduce the designs (Brannigan & Decker, 2003). Additionally, there are two supplemental tests for the Bender-Gestalt II used to provide a brief screening of specific motor and perceptual abilities. The motor and perception tests are administered directly following the recall phase and are important for better understanding an individual's low performance and potential visual-motor deficits (Brannigan & Decker, 2003).

Performance for the Bender-Gestalt II is based on the Global Scoring System, which evaluates the overall representation of each design produced during the copy and recall phases (Bender, 1938; Brannigan & Decker, 2003; Keogh & Smith, 1961). The Global Scoring System consists of a 5-point (0 to 4) rating scale that yields individual scores for each item and a total score for each phase. A score of 0 indicates the reproduction has no resemblance to the actual design or is a random drawing. If the figure bears a slight or vague resemblance it is awarded 1 point, while 2 points indicates there is a moderate likeness to the actual design. When the drawing shows a close or accurate reproduction of the figure it is given 3 points, and a score of 4 indicates the drawing is nearly perfect and identical (Bender, 1938; Brannigan & Decker, 2003; Keogh & Smith, 1961). The scoring is used to examine the discrepancies between the actual design and the examinee's drawing. The greater the difference amongst the design and the drawing produces a lower score and indicates potential visual-motor deficits (Bender, 1938; Brannigan & Decker, 2003; Keogh & Smith, 1961).

Evidence regarding the reliability and validity for the Bender-Gestalt II has indicated high reliability, validity, and internal consistency (Blakemore, 1965; Brannigan & Decker, 2003). Additionally, results from several studies have shown a high correlation with other intelligence, achievement, and visual-motor measures (Brannigan & Decker, 2003: Groth-Marnot, 2003). However, the Bender-Gestalt II has shown difficulties in precisely discriminating scores between normal and clinical populations. For example, a normal-healthy individual with a below average score and someone with a learning disability with an above average score are considered to be nearly identical and placed in the same range (Brannigan & Decker, 2003). Thus, obtaining a very low score does not provide information regarding the type of impairment that generated the test score (Brannigan & Decker, 2003). While the Bender-Gestalt II identifies

the presence of visual-motor deficits, the test is limited in determining the significant level of impairment and accurately differentiating between the various neurocognitive disorders (Blakemore, 1965; Brannigan & Decker, 2003; Groth-Marnot, 2003).

Rey Complex Figure Test (RCFT)

One of the most frequently used measures to assess visual memory and perceptual organization is the RCFT, which has become a standard component used in many neuropsychological batteries for individuals with cognitive dysfunction (Camara et al., 2000; Fastenau et al., 1991; Kaplan, 1988; Lezak, 1983, 1995; Orsini et al., 1988; Rabin et al., 2005; Rey & Osterrieth, 1993; Strauss et al., 2006; Squire, 1986; Weintraub & Mesulam, 1985). It was first established by Andre Rey (1941) and standardized by Paul-Alexandre Osterrieth (1944) to assess a number of cognitive processes including perceptual organization, visuospatial constructional ability, and visual memory (Sargenius et al., 2017; Strauss et al., 2006). The test was referred to as the Rey-Osterrieth Complex Figure Test (ROCFT) after its initial development, and since then numerous clinicians have developed or utilized some variation of the instrument's administration procedures during a neuropsychological evaluation (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019). As a result, the test has been referred to by other names including the RCFT, the Complex Figure Test (CFT), and the Rey Figure (RF) despite no significant changes or alterations to the geometric figure itself (Lezak et al., 2012; Lu et al., 2003; Meyers & Meyers, 1995; Sargenius et al., 2017; Strauss et al., 2006).

The RCFT is one of the most widely used tests of visual memory for individuals with a neurocognitive disorder. The standard administration for the RCFT is comprised of asking the patient to copy a complex geometric design on a blank sheet of paper which is tracked by the examiner (Lezak, 1989; Meyers, & Meyers, 1994; Osterrieth, 1944; Rey, 1941). This initial trial

is followed by a brief 3-minute delay, after which the examiner provides a new sheet of paper and requests the patient reproduce the design from memory. A longer delay of approximately 30 minutes is then given before the patient is asked to recreate the image again from memory. The long delay task is immediately followed by a recognition trial, in which the patient is asked to correctly identify the various components that make up the original figure (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019).

Scoring for the RCFT is based on a 36-point system and is applied to all three drawings trials. The 18 scoring units for each trial is based on criteria for both accuracy and placement ranging from 2 to 0. If the element of the figure is correctly placed and accurately reproduced the patient is awarded a full 2 points. If a part is misplaced but accurate, or correctly placed but inaccurately drawn, only 1 point is given. If a patient does not accurately draw or place the figure in the correct spot, but it is still recognizable to the evaluator, a half a point is awarded. Lastly, if the drawing is completely unrecognizable or omitted the patient is not given any points (Gagnon et al., 2003; Meyers & Meyers, 1995).

Accuracy for each of the 18 scoring units is based on specific criteria associated with that particular unit. For example, scoring unit two is a large rectangle, and to receive full credit it needs to be drawn with four distinct corners, the width should be greater than the height, and it should be roughly proportional to the overall complex figure stimulus. Placement is also based on different and precise criteria for that individual item. For example, in scoring unit two the large rectangle should be drawn approximately in the center of the page in order to receive the full 2 points (Gagnon et al., 2003; Meyers & Meyers, 1995). The recognition test is comprised of 24 geometric shapes, consisting of 12 target figures and 12 foils, and requires the patient to identify the various components that make up the initially presented design Scoring for

recognition is based on the number of true items (12) the patient is able to correctly identify (Meyers & Meyers, 1994; Meyers & Meyers, 1995; Rai et al., 2019). Each component of the RCFT has yielded solid validity and reliability results for the assessment of visual memory and perceptual organization. Thus, it is important to understand the historical development and statistical analyses for the standard administration procedures of the RCFT to assist in developing a psychometrically valid and reliable short-form version.

Psychometric History of the RCFT for Visual Memory

The RCFT has been around for over 50 years and has appeared in various forms as a standard instrument to assess visual memory in many different settings including, V.A. hospitals, academic neuropsychology training programs, rehabilitation facilities, and outpatient assessment offices (Lezak, 1989; Meyers, & Meyers, 1994; Osterrieth, 1944; Rey. 1941). However, several aspects have often contributed to increased variability in scores obtained from the RCFT. These factors involve: slightly different versions of the stimulus figure, inconsistent administration procedures and scoring instructions, poor normative data, and the comparison groups. Ultimately, these various elements of the RCFT and other potential for other mediating factors, such as anxiety, have lead to decreased accuracy in capturing true cognitive impairments in visual memory (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001).

Meyers and Meyers (1995) developed the current version of the RCFT that uses the traditional figure without modifications and established a standardized procedure with the addition of a recognition trial. The most common administration for the RCFT is comprised of asking the patient to copy a complex geometric design on a blank sheet of paper. This initial trial is followed by a 3-minute delay, after which the examiner asks the patient to reproduce the

design. A longer delay of approximately 30 minutes is then given before the patient is asked to recreate the image again from memory (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019). The long delay is followed by a recognition test that is comprised of 24 geometric shapes, consisting of 12 target figures and 12 foils, and requires the patient to identify the various components that make up the initially presented design (Meyers & Meyers, 1995; Rai et al., 2019).

Normative Sample for the RCFT

The normative sample consisted of 601 subjects who were screened for the presence of a learning disability, substance abuse, psychiatric disorders, and depression prior to being tested and included into the analyses. The number of subjects were assembled from various sources including college students (134), families and friends of rehabilitation patients (74), and community members recruited from a variety of different sources (393). Participants ranged in age from 18 to 89, and a subset of this sample (n = 394) was selected to represent the U.S. population in terms of age. Overall, the RCFT is comprised of a breakdown for the various score means and standard deviations across 14 distinct age groups (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001).

Reliability and Validity of the RCFT

Several regression analyses were conducted in order to determine the effects of age, gender, and education on RCFT scores. Age had a significant effect on all of the RCFT variables, while gender and years of education were not significantly related to a participant's score. Interrater reliability was estimated and yielded coefficients that ranged from .93 to .99, suggesting very good reliability among well-trained scorers (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001). Additionally, temporal reliability was

assessed using 12 subjects taken from the normative sample with an average retest interval of 184 days. The test-retest coefficients for Immediate Recall, Delayed Recall, and Recognition Total Correct trials were .759, .888, and .874, respectively. There were no significant differences across the two retests for the scores on the remaining RCFT variables (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001).

Convergent and discriminant validity for the RCFT were also assessed using the large normative sample and showed the immediate and delayed recall trials were highly correlated (.881) as well as positive correlations between the recall and recognition scores (Meyers & Meyers, 1995; Plake & Impara, 2001). Additionally, a group of 100 brain-injured patients was examined, which yielded a high correlation (.961) between the immediate and delayed recall scores as well as with the copy trial. Overall, the intra-test correlations for the RCFT were similar for the both the normal and brain-injured groups. When compared to other neuropsychological measures associated with visual memory and visuospatial skills, such as the BVRT and Hooper Visual Organization Test, scores on the RCFT copy, immediate, and delayed recall trials were shown to be highly correlated (Meyers & Meyers, 1995; Plake & Impara, 2001).

Factor analysis of the RCFT included visuospatial recall, visuospatial recognition, response bias, processing speed, and visuospatial constructional ability, and it was given to 30 brain-injured, 30 psychiatric, and 30 normal subjects. The analyses of variance showed significant group differences for all of the RCFT variables (Meyers & Meyers, 1995; Plake & Impara, 2001). Furthermore, a post hoc analyses indicated that the brain-injured group scored significantly lower than the other two groups on the recall trials, while the psychiatric group scored lower than the normal controls. For the other RCFT variables, the brain-injured group

scored lower than the other groups and the psychiatric and normal groups did not differ from each other (Meyers & Meyers, 1995; Plake & Impara, 2001).

Clinical Utility of the RCFT

Overall, the clinical utility of the RCFT has been well established as a very useful measure of visuospatial processing abilities, constructional abilities, and nonverbal memory (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001). The modifications made to the RCFT by Meyers and Meyers (1995) have resulted in significant improvements to the measure, such as standardized administration and a more detailed scoring system, which ultimately enhanced its usefulness and increased its reliability and validity. The extended normative data also allowed for better comparisons with age across the various groups and demonstrated adequate test-retest and interrater reliability (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001). The RCFT was also revealed to be a valid measure of cognitive dysfunction, particularly for visual memory, by showing significant differences in performance between normal healthy controls and brain-injured patients with a fairly high degree of accuracy (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001).

The RCFT has been proven to be a valuable neuropsychological test for assessing visual memory. Notably, the very high correlations between the recall trials may allow for the possibility to abbreviate the RCFT by giving only the immediate recall and excluding the long delay trial without losing the high degree of accuracy in identifying cognitive impairments. Thus, it would be important to provide further study on whether the addition of the recognition trial in a shortened version of the RCFT would provide the same degree of accuracy for identifying

cognitive deficits in visual memory (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001).

Development of Short-form Measures in Neuropsychological Assessment

Neuropsychological evaluations use standardized measures to assess higher levels of cognitive processing including attention, concentration, reasoning, problem solving, language, memory, and visuospatial skills (Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013). Brief evaluations offer several benefits over longer batteries, including quicker administration time, shorter period between testing intervals, and the ability to target specific deficits (Lezak et al., 2012; Schoenberg & Scott, 2011; Vacha-Haase, 2013). Thus, it is important to consider the length of the overall battery and test administration when determining the appropriate measures for assessing cognitive impairments for older adults. Several established neuropsychological measures have developed alternative or shortened versions to address these factors.

Seven-Subtest Short Form for the WAIS-IV

One of the most utilized intelligence measures for understanding a patient's overall cognitive abilities is the fourth edition of the Wechsler Adult Intelligence Scale (WAIS-IV), which was published in 2008 and has been shown to correlate strongly with previous editions (Meyers et al., 2013; Wechsler et al., 2008). There are 10 core subtests with an additional five supplemental that can be administered and the manual indicates overall testing time us typically between 60 to 90 minutes for the core battery (Meyers et al., 2013; Wechsler et al., 2008). While it is important to understand a patient's general intellectual abilities to help interpret their performance on other neuropsychological tests, Meyers and colleagues(2013) examined the validity of a seven-subtest form of the WAIS-IV in order to allow more focus, time, and effort on

tests that are more clinically relevant to identifying and assessing cognitive functioning related to neurological disorders (Meyers et al., 2013; Strauss et al., 2006; Ward, 1990).

One of the main advantages determined for utilizing a seven-subtest short form of the WAIS-IV is related to time allocation, since the short form version usually takes 30 to 45 min to complete rather than typical 60 to 90 minutes. As a result, the short from often saves approximately half the time on administration and allows for the emphasis of the evaluation to be more focused on specific neuropsychological measures without the concern of adding additional time and/or the possibility of increased levels of fatigue to the assessment (Meyers et al., 2013). This is particularly relevant for individuals with more severe brain injuries and psychiatric populations who may not have the stamina for a lengthy neuropsychological evaluations (Benedict et al., 1992; Callahan et al., 1997; Meyers et al., 2013). Furthermore, evidence indicates the use of a seven subtest short form version of the WAIS-IV is psychometrically similar to the full version and provides a reliable estimate of intellectual quotient (IQ). It also allows the clinician to include a range of specific measures to the overall test battery in order to focus on more neuropsychological factors contributing to the patient's potential deficits (Meyers et al., 2013).

Wechsler Abbreviated Scale of Intelligence–Second Edition (WASI-II)

A frequently utilized shortened measure of intelligence is the Wechsler Abbreviated Scale of Intelligence–Second Edition (WASI-II), which aims to provide a standardized set of subtests that can be administered in a brief format yielding a reliable measure of intelligence and general cognitive abilities (Carlson et al., 2014; Wechsler, 2011). The WASI-II was primarily designed to be an equivalent short form measure for both the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV) and the Wechsler Adult Intelligence Scale–Fourth Edition

(WAIS-IV) consisting of four primary subtests with similar items: a 13-item Block Design subtest, a 31-item expressive Vocabulary subtest, a 30-item Matrix Reasoning subtest, and a 24-item Similarities subtest (Carlson et al., 2014; Wechsler, 2011). Results obtained from the WASI-II yield information regarding an individual's level of intellectual functioning in the form of *t*-scores for each of the individual subtests and composite standard scores that include a Full Scale IQ, an index score for verbal comprehension abilities, and an index for hands on perceptual reasoning skills (Carlson et al., 2014; Wechsler, 2011). The administration time for the WASI-II is approximately 30 minutes to complete all four subtests and an even more abbreviated format, which consists of only two of the primary subtests (Vocabulary, Matrix Reasoning), can be completed within 15 minutes (Carlson et al., 2014; Wechsler, 2011). The WASI-II has been shown to be a reliable and valid abbreviated measure of intellectual functioning equivalent to the longer Wechsler scales that can be used with individuals from 6 to 90 years of age across a variety of settings including outpatient and inpatient clinics, hospitals, schools, and correctional facilities as well as other settings (Carlson et al., 2014; Wechsler, 2011).

California Verbal Learning Test-Second Edition Short Form (CVLT-II SF)

The California Verbal Learning Test (CVLT) is a widely used verbal measure to evaluate learning and memory functions in numerous populations including older adults (Delis et al., 2000; Delis et al., 2017; Rabin et al., 2005; Rabin et al., 2016). The measure often yields a relatively large amount of information regarding the processes associated with learning and memory as well as provide significant information on the presence of deficits and impairments typical of neurocognitive disorders (Carlew et al., 2019; DeJong & Donders, 2010; Greenaway et al., 2006). The California Verbal Learning Test–Second Edition Short Form (CVLT-II SF) is a nine-item version of the CVLT-II that was developed to enhance the clinical utility of the

measure, particularly as a screening tool and for individuals with more severe cognitive deficits (Carlew et al., 2019; Delis et al., 2000). Additionally, the CVLT-II SF was created as measure intended to be used for individuals who are unable to tolerate a longer exam. Some of the main differences form the standard form of the CVLT-II include only nine word items to learn over across four trials, three semantic categories, and no second distractor list of words; however, the scoring for the CVLT-II SF uses the same procedures (Carlew et al., 2019; Delis et al., 2000; Spies & Plake, 2005). Notably, a third edition of the CVLT has been made available and also includes a short-form version that is utilized in the same manner as the CVLT-II (Carlew et al., 2019; Delis et al., 2017).

Hopkins Verbal Learning Test-Revised (HVLT-R)

The Hopkins Verbal Learning Test (HVLT) is a verbal learning and memory measure developed as a comprehensive and brief memory test often used for individuals that are more difficult to test to or have severe impairments (Brandt, 1991; Vanderploeg et al., 2000). Initially the HVLT lacked delayed recall or recognition trials, and consequently it was revised to include a delay period while also continuing to maintain its brevity (Benedict et al., 1998; Brandt, 1991; Vanderploeg et al., 2000). The HVLT-R consists of a 12-item word list presented over three consecutive learning trials that is followed by a 20-25 minute delay before a free recall trial and a yes/no recognition task is administered (Benedict et al., 1998; Vanderploeg et al., 2000). Notably, the HVLT-R has also shown adequate reliability and convergent validity with the CVLT indicating it can be clinically useful as a comprehensive and brief measure for the assessment of memory (Benedict et al., 1998; Lacritz & Cullum, 1998; Vanderploeg et al., 2000).

Mini Mental Status Exam (MMSE)

One of the most widely administered cognitive screening instruments is the Mini-Mental State Examination (MMSE), which has been used in numerous settings and with various population across the world (Folstein et al., 1975; Tombaugh and McIntyre, 1992; Van Patten et al., 2018). The MMSE is comprised of 11 items with a short administration time of approximately 5-10 minutes and provides information on several important cognitive domains including attention, language, visuospatial and construction abilities, and short-term verbal memory. This makes the MMSE a favorable measure to use in clinical settings as well as its high internal consistency, reliability, and validity for distinguishing dementia from healthy aging (Folstein et al., 1975; Mitchell, 2009; Mitrushina & Satz, 1991; Van Patten et al., 2018). The MMSE is a useful measure for detecting moderate to severe cognitive impairments; however, it is typically limited in the ability to accurately identify subtle cognitive decline most often associated with aging (Tombaugh and McIntyre, 1992; Van Patten et al., 2018).

Short Montreal Cognitive Assessment (s-MoCA)

Since the Montreal Cognitive Assessment (MoCA) form was developed it has become a commonly used measure for screening of cognitive impairments (Nasreddine et al., 2005). It has been applied across many different clinical settings and also has good diagnostic utility for identifying cognitive deficits (Davis et al., 2015; Julayanont & Nasreddine, 2017; Larner, 2017; Tsoi et al., 2015). However, the MoCA is often used infrequently in primary care settings due to the administration time being viewed as too long for regular use (Wojtowicz & Larner, 2015). As a result, a short form of the MoCA (s-MoCA) was developed based on 8 items with an administration time estimated at around 5 minutes (Kaur et al., 2013; Larner, 2017; Roalf et al., 2016). Results indicate the s-MoCA is highly correlated with the standard MoCA administration

procedures and has similar accuracy in correctly classifying cognitive impairments (Larner, 2017; Roalf et al., 2016).

Short-form of the Face-Name Associative Memory Exam (FNAME-12)

The Face Name Associative Memory Exam (FNAME) is an associative memory test that requires individuals learn 16-novel pairs associated with pictures of unfamiliar faces that have common names and occupations (Papp et al., 2014; Rentz et al., 2011). While this measure has shown to be sensitive for detecting impairments in cognitive functioning, the FNAME is often challenging for older adults due to the length of the administration time and the increased attentional demands it requires to track all of the stimuli (O'Brien et al., 2010; Papp et al., 2014; Rentz et al., 2011). As a result, a modified 12-item version of the FNAME (FNAME-12) was developed that contained fewer stimuli, added more learning trials, and provided a delayed recognition task for older adults (Papp et al., 2014). Results indicated the FNAME-12 was psychometrically equivalent to the original FNAME-16 form and was also correlated to other measures of memory regarding sensitivity to impairments due to the additional learning and cued recall trials (Papp et al., 2014).

Factors Impacting Performance for Older Adults

Fatigue

Older adults typically demonstrate signs of fatigue more quickly during a neuropsychological evaluation, and it has been discovered as an important factor contributing to lower test scores as well as poor cognitive performance (American Psychological Association Presidential Task Force, 1998; Banerjee et al., 2020; Lezak, 1995; Utll et al., 2000; Woodruff-Pak, 1997). Fatigue is often characterized as a lack of physical and mental energy that interferes with the ability to complete daily activities and is one of the most common complaints for older

adults seeking treatment (Banerjee et al., 2020; Miller, 1998). Furthermore, fatigue is a factor that is often associated with various negative outcomes including higher incidents of disability and hospitalizations as well as increased cognitive decline in older adults (Banerjee et al., 2020; Lin et al., 2013; Moreh et al., 2010; Vestergaard et al., 2009). Higher levels of fatigue have been linked to cognitive deficits in several areas including decreased attention, inefficient information processing, poor executive functioning and reasoning abilities, delayed psychomotor speed, and impaired memory (Banerjee et al., 2020; Carvalho et al., 2017; Lin et al., 2013). Additionally, older adults experiencing increased levels of fatigue generally perform worse across all the different cognitive domains when compared to individuals with minimal amounts of fatigue (Banerjee et al., 2020; Carvalho et al., 2017).

A neural model examining fatigue's impact on cognitive functioning posits that dysfunction in the basal ganglia and the associated cortical connections can lead to suppressed frontal activation causing an array of changes including decreased motivation and increased expenditure of physiological and mental energy (Banerjee et al., 2020; Chaudhuri & Behan, 2004). Neuroimaging studies have also shown evidence that higher fatigue levels are associated with structural and functional changes within the basal ganglia and prefrontal cortex (Andreasen et al., 2010; Banerjee et al., 2020; Calabrese et al., 2010; Nakagawa et al., 2016; Okada et al., 2004; Pavese et al., 2010; Roelcke et al., 1997; Tang et al., 2010). As a result, fatigue in older adults may be a sign of problems within the frontostriatal system leading to significant cognitive decline and impairments in functioning (Banerjee et al., 2020; Chaudhuri & Behan, 2004).

Anxiety

Referral for a neuropsychological evaluation often produces stress and anxiety for individuals that can negatively impact their performance, and this is particularly true for older

adults (Dorenkamp & Vik, 2018; Orr, 2010; Owen, 2012). There are several major issues older adults often express as their biggest concerns regarding neuropsychological testing. For example, they may have negative memories of being tested in school leading to anxiety over being evaluated. Also, older adults report feeling embarrassed or ashamed for not knowing an answer and are cognizant of the potential threats identified cognitive impairments have on their ability to continue living independently. Finally, older adults report feeling distressed and worried over the stigma usually associated with age-related cognitive deficits or being diagnosed with a neurodegenerative disorder (Dorenkamp & Vik, 2018; Garand et al., 2009; Orr, 2010).

The association between anxiety and test performance is complex and varied with regards to the significant impact it has on cognition. High and low levels of anxiety have shown to be equally correlated with lower test scores, yet moderate levels have often produced higher test scores indicating some level of anxiety can serve as an adaptive function (Dorenkamp & Vik, 2018; Eysenck et al., 2007; Knox & Grippaldi, 1970; Teigen, 1994). High levels of anxiety are believed to interfere with attention by directing focus away from the task at hand and shifting an individual's cognitive effort to the perceived threat, which negatively impacts performance (Dorenkamp & Vik, 2018; Eysenck et al., 2007). Anxiety can often be categorized into two distinct types, trait and state, which are associated with non-specific anxious arousal. Trait anxiety is characterized as an individual's tendency to repeatedly respond to specific circumstances or stimuli perceived as threatening with arousal, distress, and persistent worry across situations. (Dorenkamp & Vik, 2018; Endler & Kocovski, 2001). State anxiety is considered to be an emotional response caused by a perceived situational threat in the current moment that resolves once the alleged threat has passed (Croyle et al., 2012; Dorenkamp & Vik, 2018; Potvin et al., 2013).

Anxiety can also be further classified into several other types that are associated with specific arousal-evoking contexts or stimuli including social and test anxiety (Dorenkamp & Vik, 2018). Social anxiety is characterized as a marked fear of social situations in which the individual is exposed to possible scrutiny or being negatively evaluated by others, such as having a conversation, being observed while eating, or giving a speech (American Psychiatric Association, 2013). Test anxiety is elicited when an individual enters a setting in which they will be evaluated and perceive as threatening. Additionally, it has been observed as both a state and trait type of anxiety. As a trait, test anxiety is described as a personality characteristic due to the intense and distressing symptoms persisting beyond the specific testing situation. While test anxiety as a state is considered to be a brief and momentary response to a specific testing encounter (Croyle et al., 2012; Dorenkamp & Vik, 2018).

Another element frequently observed to influence cognitive performance is stress, which is defined as the biological and physiological reaction to environmental stressors that threaten an individual (Dorenkamp & Vik, 2018; Hoffman & Al' Absi, 2003; Lazarus, 1993; Sarason, 1984; Sun & Alkon, 2014). Acute stress often arises in the current moment and causes the activation of the hypothalamic-pituitary-adrenal (HPA) axis, which activates the sympathetic nervous system (Friedel et al., 2015; Hoffman & Al' Absi, 2003). Furthermore, the HPA axis leads to physiological changes as evidenced by measures associated with increased heart rate, high blood pressure, and elevated cortisol levels, which may resolve quickly or continue for extended periods of time (Dorenkamp & Vik, 2018; Hanna-Pladdy et al., 2001). Whether an individual experiences an acute stress response or has high levels of anxiety, they largely exhibit the same physiological markers that can negatively impact cognitive functioning leading to poor test

performance (Dorenkamp & Vik, 2018; Hoffman & Al' Absi, 2003; Hopko et al., 2005; Mutchnik & Williams, 2012).

A neuropsychological evaluation often elicits high levels of stress and anxiety for individuals that can persist throughout testing and influence performance (Dorenkamp & Vik, 2018; Gass & Curiel, 2011). The assessment experience itself may be overwhelming and fears of receiving a diagnosis of a neurodegenerative disease can also contribute to significant levels of stress and anxiety. Additionally, the potential loss of independence and becoming a burden to family or loved ones tend to further exacerbate the high levels of anxiety and stress during a neuropsychological evaluation (Gass & Curiel, 2011; Williams et al., 2017). Individuals with significant anxiety may have considerable worries and experience mental intrusions that can be extremely disruptive and interfere with their cognition. As a result, findings from a neuropsychological evaluation might be misinterpreted as deficits in functioning and underestimate their true cognitive abilities (Gass & Curiel, 2011; Mutchnik & Williams, 2012).

Older adults experiencing higher levels of anxiety have been associated with significant memory deficits and on tasks evaluating memory exhibit a greater decline in cognitive functioning (Beaudreau and O'Hara, 2009; Butters et al., 2011; Kizilbash et al., 2002; Lyche et al., 2011; Rexroth et al., 2013; Williams et al., 2017). Moreover, research has indicated higher levels of anxiety lead to reduced immediate and delayed recall abilities on verbal and visual memory tasks (Davidson et al., 1991; Leininger & Skeel, 2012; Stillman et al., 2012; Williams et al., 2017). Thus, it is important to continue establishing neuropsychological measures and examine means of differentiating memory problems and impairments from merely typical struggles caused by anxiety or associated with normal aging.

CHAPTER 3: METHODS

The primary objective of this research study was to establish a short-form version of the RCFT-SF and its ability to capture significant visual memory impairments in an adult population. In addition, the study assessed if a short-form version of the RCFT produced results consistent with the standard RCFT administration procedures. The study also examined the impact of age and psychosocial factors, specifically anxiety, on visual memory performance for older adults. Participants were recruited from two outpatient hospital-based neuropsychology practices referred for evaluation of a potential neurocognitive disorder.

Design

A matched subjects, correlational design was employed to assess the clinical utility and psychometric properties of a short-form version of the RCFT by comparing scores on this instrument with scores from the standard form. The impact of psychosocial factors on cognitive performance, specifically anxiety, was also evaluated through a self-report measure for individuals enrolled from the recruitment sites. Participants were matched based on their age, gender, and education level. Additionally, participants from each group were matched based on their level of cognitive impairment according to *t*-scores associated with their OTBM score determined from their performance on the MNB.

Participants

In order to collect a significant sample that may be representative of the older adult population, participants were recruited from two outpatient hospital-based neuropsychology practices: one located in Wilmington, Delaware and the other based in Cherry Hill, New Jersey. The principal reason for referral and evaluation was to assess the individual's subjective cognitive complaints, specifically difficulties with memory (i.e., remembering information,

forgetfulness) for participants in the RCFT-SF condition. Additionally, participants in the control condition were collected from a previously administered neuropsychological evaluation at the recruitment sites that contained scores from the standard RCFT measure. All participant information obtained from both conditions (RCFT-SF and control) was de-identified, stored in locked filing cabinets, and then entered into a secure electronic file for subsequent analyses.

Inclusion Criteria

Participants were required to meet the following conditions to be eligible for participation in this study. Individuals were required to be within the age range of 65 – 89 and have at least an eighth grade education. The cutoff age for this study was established by the traditional conceptions of healthy older adults, which is defined as age 65 and older (Baltes & Smith, 2003). Also, the age range was based on a sample of convenience from the participating recruitment sites. All participants were able to speak fluent English and reside in the United States.

Exclusion Criteria

Participants who were younger than 65 years of age or older than 89 years of age were excluded from the study. Individuals who were unable to speak English fluently were also not eligible to participate. Any individual that did not have at least an eighth grade education or a significant intellectual disability present from childhood were excluded from participation. Individuals with a current alcohol and/or drug abuse problem were not eligible. Any individual that received a previous diagnosis for a major psychiatric illness, such as anxiety, depression, bipolar, schizophrenia, or any personality disorder, were also ineligible. Finally, individuals whose vision was drastically compromised so they were not sufficiently able to observe the visual stimulus was ineligible. This was determined by reviewing their medical records for information regarding a previous neurological or ophthalmological examination identifying

visual acuity as being no worse than 20/70, which has shown to be the threshold for impacting reliable and valid test results. Finally, participants who failed two performance validity measures (PVMs), the Memory Error Pattern (MEP) and Estimated Visual Memory, on the Meyers Neuropsychological Battery (MNB) were ineligible for the study.

PVMs are used in neuropsychological evaluations, either externally or embedded within a particular measure, as a method for objectively evaluating a patient's effort during testing. The MEP in the MNB examines the relationship between the patient's scores on the RCFT immediate, delayed, and recognition trials in order to create a profile associated with different aspects of memory (e.g., attention, encoding, storage, retrieval, consolidation; Meyers & Volbrecht, 1999, 2003). A patient is considered to have a failed PVM on the MNB if they produce an MEP score associated with attention, encoding, or storage, since these are typically only expected within individuals who have significant cognitive impairment (Meyers & Meyers, 1995; Meyers & Volbrecht, 1999, 2003). An attention MEP is identified when the patient's scores on the CFT immediate, delayed, and recognition scores all below a *t*-score of 20 (Meyers & Meyers, 1995). This pattern suggests the individual is not able to attend to the information being presented and is unable to recall even when provided cues (Meyers & Meyers, 1995; Meyers & Volbrecht, 1999, 2003). An encoding MEP occurs when the scores on the CFT immediate and delayed trials are below a *t*-score of less than 20 and the score on the recognition trial is higher than a *t*-score of greater than 20 (Meyers & Meyers, 1995). This pattern suggests information was not perceived accurately yet the individual is able to accurately identify information when provided cues (Meyers & Meyers, 1995; Meyers & Volbrecht, 1999, 2003). Lastly, the storage MEP is identified when the *t*-score from the immediate trial is higher than the delayed trial which is higher than the *t*-score on the recognition trial. This pattern suggests that

information is lost due to poor storage and cannot be recalled even with cures (Meyers & Meyers, 1995; Meyers & Volbrecht, 1999, 2003). As a result, participants were considered ineligible if failure on two PVMs occurred.

Prior to participating in the study, patients underwent a comprehensive diagnostic interview to initially assess their age, the severity of memory impairments, and were queried about their vision. Questions involved asking their age, how long they have been dealing with their memory problems, what daily activities are impacted (e.g., driving, following directions/getting lost, managing finances, shopping, cooking, cleaning, taking medications, scheduling/keeping appointments, etc.), their visual acuity, do they wear corrective lenses and if so what type (e.g., bifocal, progressives, etc.). The same exclusion criteria were utilized for all of the control participants collected from previous neuropsychological evaluations including all background information from the written report and reviewing their medical records for visual acuity.

Measures

Rey Complex Figure Test (RCFT; Lezak, 1989; Meyers, & Meyers, 1994; Osterrieth, 1944; Rey, 1941). The RCFT is one of the most widely used tests of visual memory for individuals with a neurocognitive disorder. The standard administration for the RCFT is comprised of asking the patient to copy a complex geometric design on a blank sheet of paper which is tracked by the examiner. This initial trial is followed by a brief 3-minute delay, after which the examiner provides a new sheet of paper and requests the patient reproduce the design from memory. A longer delay of approximately 30 minutes is then given before the patient is asked to recreate the image again from memory immediately followed by a recognition trial, in

which the patient is asked to correctly identify the various components that make up the original figure (Fastenau et al., 1991; Meyers & Meyers, 1995; Rai et al., 2019).

Scoring for the RCFT is based on a 36-point system and is utilized across the three trials. The 18 scoring units for each trial is based on criteria for both accuracy and placement ranging from two to zero. If the element of the figure is correctly placed and accurately reproduced the patient is awarded a full 2 points. If a part is misplaced but accurate, or correctly placed but inaccurately drawn, only 1 point is given. If a patient does not accurately draw or place the figure in the correct spot, but it is still recognizable to the evaluator a half a point is awarded. Lastly, if the drawing is completely unrecognizable or omitted the patient is not given any points (Gagnon et al., 2003; Meyers & Meyers, 1995). The recognition trial is comprised of 24 geometric shapes, consisting of 12 target figures and 12 foils, and requires the patient to identify the various components that make up the initially presented design. Scoring for recognition is based on the number of true items (12) the patient is able to correctly identify and also factors in the number of true negatives or false positives made (Meyers & Meyers, 1994; Meyers & Meyers, 1995; Rai et al., 2019). The RCFT has shown good interrater reliability, high test-retest coefficients, solid convergent and discriminant validity, and high correlations with other visual memory tests (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001). In this study, the short form version of the RCFT will adhere to the same scoring system as the standard administration for the copy, recall, and recognition trials.

State-Trait Anxiety Inventory (STAI; Spielberger, 1983). The STAI is a self-report measure aimed at detecting the presence and severity of current symptoms of anxiety. Also, it evaluates an individual's propensity to be anxious. Versions of the STAI are available for both adults and children (Julian, 2011; Spielberger, 1983). There are two subscales within the STAI.

The first subscale measures state anxiety (S-Anxiety), which evaluates the individual's current level of anxiety by asking how the individual feels at that particular moment and assessing their subjective feelings. The second subscale measures trait anxiety scale (T-Anxiety), which evaluates an individual's proneness to feeling anxious and worried (Julian, 2011; Spielberger, 1983). The STAI has 40 items total, with 20 items allocated to each the subscales. Responses for the S-Anxiety scale assess intensity of current feelings "at this moment" ranging from: 1 = *not at all*, 2 = *somewhat*, 3 = *moderately so*, and 4 = *very much so*. Responses for the T-Anxiety scale assess frequency of feelings "in general" ranging from: 1 = *almost never*, 2 = *sometimes*, 3 = *often*, and 4 = *almost always* (Julian, 2011; Spielberger, 1983). Scores range between 20-80 for each subtest, with higher scores indicating greater levels of anxiety. A cutoff point of 39 on the state scale and 40 on the trait scale has been suggested to detect clinically significant symptoms for the anxiety scales, while other studies have suggested a higher cutoff score of 54 on the state scale and 55 on the trait scale for older adults (Addolorato et al., 1999; Julian, 2011; Knight, et al., 1983; Kvaal et al., 2005; Spielberger, 1983).

The normative sample for the STAI was extremely large and tested both adults and adolescents. The breakdown consisted of 377 high school juniors, 982 college freshmen, 484 college students enrolled in an introductory psychology course, 461 male neuropsychiatric patients, 161 general medical and surgical patients, and 212 prisoners (Julian, 2011; Knight, et al., 1983; Spielberger, 1983). Test-retest reliabilities were given at various time intervals and separated by gender. At the one-hour interval the test-retest reliabilities were .33 (males) and .16 (females) for state, while .84 and .76 for trait. At the 20 day interval the test-retest reliabilities were .54 and .27 for state, .86 and .76 for trait. Finally, at the 104 day interval the test-retest reliabilities were .33 and .31 for state, .73 and .77 for trait (Julian, 2011; Knight, et al., 1983;

Kvaal et al., 2005; Spielberger, 1983). Alpha reliability coefficients for the normative samples ranged from .83 to .92 for state scores and .86 to .92 for trait scores (Julian, 2011; Knight, et al., 1983; Kvaal et al., 2005; Spielberger, 1983). The validity of the STAI was estimated by comparing the obtained scores to results from other anxiety measures, specifically the Taylor Manifest Anxiety Scale and Cattell and Scheier's Anxiety Scale Questionnaire. Overall correlations between the STAI and these two measures were 0.73 and 0.85, respectively (Cattell & Scheier, 1963; Julian, 2011; Taylor, 1953).

Procedure

Participants involved with this study were divided into two categories: one group was administered the RCFT-SF along with an anxiety measure (STAI), while the other group was already tested with the standard RCFT. Participants for the RCFT-SF condition were approached at the time of their scheduled appointment, while the other set of participants were gathered from previously administered neuropsychological evaluations. Participants in the first group were fully informed about the study's purpose and procedures. They were notified that participation was completely voluntary and given the right to withdraw from the study at any time without explanation or any repercussion. When the participant agreed to be enrolled in the study, they were given a consent form to sign. All participants were asked to complete the RCFT and all of the questions on the STAI to the best of their ability.

Following the diagnostic interview and during the appropriate point in the neuropsychological evaluation, administration of the RCFT-SF was carried out in a similar manner to the standard form. First, participants were asked to copy the RCFT on a blank sheet of paper provided by the evaluator. Although the time it takes to for copy the figure was monitored, the participant was not given a time limit or allowed to erase any of their drawing. Participants

were given these specific instruction to follow: *"See this figure, I would like you to copy it here* (point to blank page). *Please copy it so that I know this is the figure you drew. Do the best that you can."* After completing the figure, the participant's drawing along with the stimulus were removed and the time it took to complete the copy was noted. The initial copy trial was followed by a 3-minute delay filled with other verbal tasks or simple conversation. Participants were then asked to recreate the RCFT from memory on a new clean sheet of paper. They were provided with the following instructions: *"Remember a few minutes ago I had you copy a figure. I would like you to draw that figure again from memory here."* The participant was given encouragement to *"do the best you can,"* if they seemed to be having difficulties starting. After completing this trial, a 10-minute delay period was given before the participants were asked to draw the RCFT from memory again using the same instructions as before. Timing for the delay period immediately began once the participant finished copying the figure. Additionally, the 10-minute delay was filled with verbal distractors including: educational and reading materials, other verbal testing measures, or general conversation. Once the 10-minute delay was completed, the recognition trial was given. The participants were provided the following instructions: *"Circle the figures that were part of the larger whole design you copied then drew. Each figure is facing the same direction as in the original design. There are four pages. When you are ready, turn the page and begin."* Scoring for the participant's drawings from each trial and recognition subtest for the RCFT-SF followed the same guidelines as the standard administration originally outlined by Lezak (1989) and revised by Meyers, & Meyers (1992). The RCFT-SF was administered the same number of trials to remain consistent with the administration procedures of the standard RCFT form including an initial copy phase, an immediate recall trial, a delayed recall trial, and followed by a recognition trial. However, the period between the immediate and delayed recall

portions of the RCFT was reduced from 30 to 10 minutes on the short-form version. Following the administration of the RCFT-SF, participants were given the STAI to complete and the directions for filling out the form were reviewed.

Upon completion of the neuropsychological evaluation, participants from both cohorts were matched to individuals based on age, gender, education level, and *t*-scores associated with their OTBM score obtained from their performance on the MNB. Review of the participant's scores for both performance validity measures, MEP and Estimated Visual Memory, to determine eligibility was conducted.

Once all of the information was collected from the MNB, RCFT and STAI, the data from participants in both the RCFT-SF and control conditions was de-identified and stored in locked filing cabinets located at each of the recruitment sites. Consent forms were also be stored in a separate locked filing cabinet at each of the recruitment sites. Storage for all of paper hard copies of the data was overseen by the responsible investigator with approval from the principal investigator and was accountable for maintaining their security throughout the study. All relevant study information including demographics, scores from all trials for both versions of the RCFT, and results from the anxiety measure were entered into a secure electronic file for subsequent data analyses.

CHAPTER 4: RESULTS

Demographic Analyses

Descriptive analyses were computed for demographic variables, including age, gender, and education level (Table 1). A total sample of 124 participants were included in the analyses and divided into two groups: the RCFT-SF (*n*= 37) and Control (*n*= 87). Participants ranged in age from 65-86, with a mean age of 71. Their education level ranged from 8-20 years with a mean of 15. The sample consisted of 61 females (49.2%) and 63 males (50.8%).

Table 1

Demographic Characteristics of Participants (N = 124)

Variables	*n*	%	Mean
Age	65-86	--	71.73
Gender			
Female	61	49.2%	--
Male	63	50.8%	--
Education Level	8-20	--	15.08

Statistical Analyses

Hypothesis I Analysis

To evaluate whether the RCFT-SF identified cognitive impairments in visual memory across the copy, recall, and recognition trials on the RCFT equivalent to the standard administration procedures scores, an independent samples *t*-test was performed. Prior to conducting the independent samples *t*-test (RCFT-SF vs Control), assumptions were assessed. Analyses indicated that the outcome data obtained from the Delayed Recall Score for both groups and the Recognition score for the short-form group were normally distributed, while the outcome data for the Copy and Immediate Recall trials for both groups, and the Recognition Trial for the control group significantly deviated from a normal distribution (Table 2).

Table 2

Tests of Normality for the RCFT-SF Immediate, Delayed, and Recognition Trials for the Control Group (N = 87) and Short-Form Group (N = 37)

Subscale		Kolmogorov-Smirnov			Shapiro-Wilk		
		Statistic	*df*	Sig.	Statistic	*df*	Sig.
RCFT Copy	Control	.200	86	.000	.846	86	.000
	SF Group	.185	34	.005	.926	34	.024
RCFT – Immediate	Control	.091	86	.077	.966	86	.022
	SF Group	.151	34	.048	.919	34	.016
RCFT – Delayed	Control	.061	86	.200*	.984	86	.360
	SF Group	.104	34	.200*	.975	34	.602
RCFT – Recognition	Control	.085	86	.185	.963	86	.015
	SF Group	.106	34	.200*	.963	34	.294

*This a lower bound of the true significance

An independent samples *t*-test was completed to evaluate differences between the Control Group and RCFT-SF group on the RCFT Delayed Recall trial. The scores obtained from the delayed recall trial did not have heterogeneity of variances across the two groups (Control vs. SF-group), so the significance value for equal variances assumed was used ($p = .741$). Results indicated there was no significant difference found in the scores for the RCFT ($M = 41.92$, $SD = 15.51$) and the RCFT-SF ($M = 43.47$, $SD = 15.76$) conditions, $t\ (119) = -.429$, $p = 0.624$ (Table 3). This finding suggests the delay period (e.g., 10 minutes) for the RCFT-SF administration procedure is equivalent to the delay period (e.g., 30 minutes) in the standard RCFT administration procedure.

Table 3

Independent Samples t-test for RCFT (N = 87) and RCFT-SF (N = 34) Delay Trial

	RCFT		RCFT-SF					
Subscale	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
RCFT – Delay	41.92	15.51	43.47	15.76	-.492	119	.624	-.100

Due to deviation from a normal distribution for the resulting data concerning the RCFT Copy, Immediate, and Recognition trials, a nonparametric Mann-Whitney U test was performed. Results from the RCFT Copy Trial indicated there was a significant difference between groups, with the mean for RCFT-SF group was 35.32, whereas the mean for RCFT group was 41.98. As such, these results indicate that participants in the RFCT group had significantly higher scores than the RCFT-SF group ($U = 1118.50$, $p = .013$; Table 4). The results from the Immediate Trial indicated that there was no significant difference between the RCFT ($M = 41.34$, $SD = 14.55$) and RCFT-SF ($M = 44.09$, $SD = 14.64$). Additionally, the results from the Recognition Trial indicated there was no significant difference between the RCFT ($M = 39.15$, $SD = 17.54$) and the RCFT-SF ($M = 38.50$, $SD = 16.03$; Table 5 & 6).

Table 4

Independent Samples Mann-Whitney U for RCFT (N = 87) and RCFT-SF (N = 36) Copy Trial

	RCFT		RCFT-SF		
Subscale	*M*	*SD*	*M*	*SD*	Asymptotic Sig (2-sided)
RCFT – Copy	41.98	16.01	35.32	17.61	.013

Table 5

Independent Samples Mann-Whitney U for RCFT (N = 87) and RCFT-SF (N = 36) Immediate Trial

	RCFT		RCFT-SF		
Subscale	*M*	*SD*	*M*	*SD*	Asymptotic Sig (2-sided)
RCFT – Immediate	41.34	14.55	44.09	14.64	.246

Table 6

Independent Samples Mann-Whitney U for RCFT (N = 87) and RCFT-SF (N = 36) Recognition Trial

	RCFT		RCFT-SF		
Subscale	*M*	*SD*	*M*	*SD*	Asymptotic Sig (2-sided)
RCFT – Recognition	39.15	17.54	38.50	16.03	.156

Finally, an independent samples *t*-test was used to determine if participant age differed between the RCFT and RCFT-SF groups. The scores had heterogeneity of variances across the two groups (RCFT vs. RCFT-SF), so the significance value for equal variances not assumed was used ($p = .017$). Results indicated there was a significant difference in age between the RCFT ($M = 70.89$, $SD = 4.86$) and the RCFT-SF ($M = 73.70$, $SD = 6.17$) conditions; $t\ (56) = -2.47$, $p = 0.017$ (Table 7). This finding suggests individuals in the RCFT-SF administration procedure were significantly older than participants in the standard RCFT administration procedure.

Table 7

Independent Samples t-test for Age

	RCFT		RCFT-SF					
Subscale	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
RCFT	70.89	4.86	73.70	6.17	-2.47	56	.017	-.534

Hypothesis II Analysis

To evaluate whether higher levels of state and trait anxiety were associated with impaired performance on the RCFT-SF, scores for the immediate recall, delayed recall, and recognition trials were compared using a series of Pearson correlation analyses. Descriptive statistics are shown in Table 8 demonstrating a mean *t*-score of 53.70 on the state scale and a mean *t*-score of 56.78 on the trait scale, which are equivalent and slightly above the commonly used cutoff scores of 54 (state) and 55 (trait) to define the likely presence of clinical levels of anxiety.

Table 8

Descriptive Statistics for STAI

Variables	Mean	Standard Deviation	N
STAI – State	53.70	13.54	37
STAI – Trait	56.78	15.86	37

Results from the Pearson correlation analyses are shown in Table 9 and indicated there was no significant relationship between state level of anxiety on the STAI and the RCFT-SF Immediate Recall r (34) = -.316, p = .060, Delayed Recall r (32) = -.275, p = .116, or Recognition Trial r (32) = -.174, p = .325. Additionally, there was no significant relationship found between trait level of anxiety on the STAI and the RCFT-SF Immediate Recall r (34) = -.142, p = .409, Delayed Recall r (32) = -.046, p = .794 or Recognition Trial r (32) = -.232, p = .187. As a result, anxiety was not related to the participant's ability to recall the figure and the null hypothesis was not rejected.

Table 9

Summary of Pearson Correlations Between STAI State/Trait and RCFT-SF Immediate Recall, Delayed Recall, and Recognition Trials

Measure	RCFT-SF Immediate	RCFT-SF Delayed	RCFT-SF Recognition
STAI – State	.060	.116	.325
STAI – Trait	.409	.794	.187

**Correlation is significant at the 0.01 level (2-tailed)
*Correlation is significant at 0.05 level (2-tailed)

Hypothesis III Analysis

To evaluate whether older adults with cognitive impairment will have lower scores on the RCFT-SF when compared to those who are unimpaired, a series of independent samples t-tests were conducted. Level of impairment was determined using the participant's OTBM score (impaired < 40; unimpaired ≥ 40). The number of participants who completed the RCFT-SF in the impaired group was 7 (19.4%) and the unimpaired group had 29 (80.6%; Table 10).

Table 10

Frequencies of Participants that completed RCFT-SF who were Impaired and Unimpaired with cutoff of T-score <40 or >40 (N = 36)

Variables	*n*	%
Impaired	7	19.4

Unimpaired	29	80.6

Additionally, level of impairment was reviewed using comparison points from the MNB (e.g., OTBM and Premorbid Estimate). The number of participants who completed the RCFT-SF in the impaired group was 4 (11.1%) and the unimpaired group had 32 (88.8%; Table 11). No significant difference was evidenced between the two methods, with both resulting in an insufficient number of impaired participants for analysis purposes. Therefore, the cutoff score of less than 40 was used in this study to indicate level of impairment.

Table 11

Frequencies of Participants that completed RCFT-SF who were Impaired and Unimpaired with MNB cutoff T-score (N = 36)

Variables	*n*	%
Impaired	4	11.1
Unimpaired	32	88.8

A series of independent samples *t*-test were completed to evaluate differences between the impaired group and the unimpaired group performances on the RCFT-SF immediate, delayed, and recognition trials. Scores on the delayed trial indicated homogeneity of variances across the two groups (impaired vs. unimpaired), so the significance value for equal variances assumed was used ($p = .443$). The scores on the recognition trial had heterogeneity of variances across the two groups (impaired vs. unimpaired), so the significance value for equal variances not assumed was used ($p = .016$). Results indicated there was no significant difference found across the delayed trial t (31) = -1.35, $p = .188$ between the impaired group ($M = 37.00$, $SD = 10.50$) and unimpaired group ($M = 45.88$, $SD = 16.48$). Additionally, no significant difference was found across the recognition trial t (23) = -.373, $p = .713$ between the impaired group ($M = 37.71$, $SD = 7.99$) and unimpaired group ($M = 39.42$, $SD = 17.58$; Table 12).

Table 12

Independent Samples t-test for Impaired (N = 7) and Unimpaired (N = 28) Delay & Recognition Trial for the RCFT-SF

	Impaired		Unimpaired					
Subscale	*M*	*SD*	*M*	*SD*	*t*	*df*	*p*	Cohen's *d*
RCFT-SF – Delay	37.00	10.50	45.88	16.48	-1.35	31	.188	-.573
RCFT-SF - Recognition	37.71	7.99	39.42	17.58	-.373	23	.713	-.106

These results indicate that level of impairment did not impact performance on the delayed and recognition trials on the RCFT-SF. However, the immediate recall score violated the assumption of normality for the impaired group. Therefore a nonparametric Mann-Whitney U test was performed. A significant difference was identified between the impaired group (M = 35.86, SD = 14.33) and unimpaired group (M = 48.07, SD = 14.32), with impaired individuals scoring significantly lower than the unimpaired on the immediate recall trial for the RCFT (Table 13).

Table 13

Independent Samples Mann-Whitney U for Impaired (N = 7) and Unimpaired (N = 28) on the RCFT Immediate Recall Trial

	Impaired		Unimpaired		
Subscale	*M*	*SD*	*M*	*SD*	Exact Sig. (2-sided-test)
RCFT – Immediate	35.86	14.33	48.07	14.32	.015

Descriptive statistics for both the control group and SF-group on the RCFT-SF are shown in Table 14 demonstrating a mean t-score of 42.02 on the copy trial and a mean t-score of 41.28 on the immediate recall trial for the control group. Additionally, the SF-group demonstrated a mean t-score of 34.58 on the copy trial and a mean t-score of 45.14 on the immediate recall trial.

Table 14

Descriptive Statistics for RCFT-SF Copy and Immediate trials

	Control	SF-Group

Subscale	M	SD	N	M	SD	N
RCFT-SF – Copy	42.02	15.92	87	34.58	17.69	36
RCFT-SF- Immediate	41.28	14.48	87	45.14	15.03	36

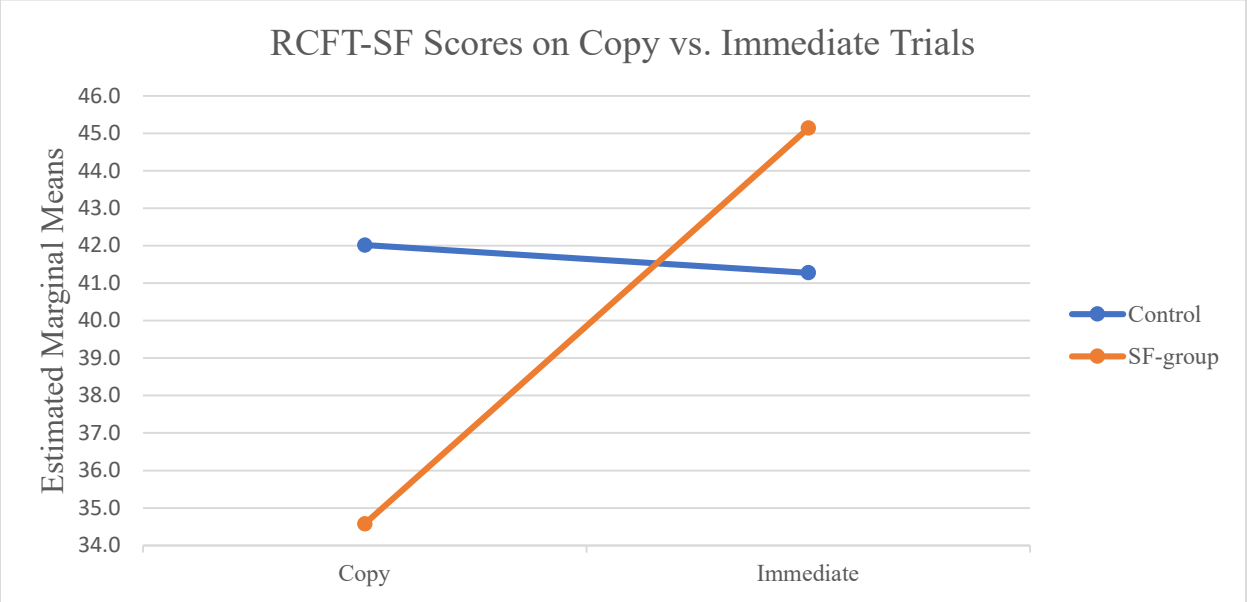
A 2 x 2 mixed design ANOVA was used to evaluate if there was a difference across scores on the copy and immediate recall trials between the RCFT-SF and control groups. Box's *M* was not significant ($p = .626$) indicating equality of covariance matrices between the groups (SF-group vs. control). Results indicated the difference between the copy and immediate recall scores is dependent on whether someone was in the control or SF-group, $F(1, 121) = 13.37$, $p < .001$. Those in the SF-group performed significantly worse on the copy trial compared to the control, but then slightly outperformed the control on the immediate recall trial. The $p < .001$ indicates a significant interaction effect, and the partial eta squared at .099 indicates a moderate effect size (Table 15). As a result, the difference between the SF-group and the control group was different depending on the copy or immediate recall trial. The difference was largest for the copy trial with the SF-group performing worse than the control; however, the SF-group then slightly outperformed the control group during the immediate recall trial (Figure 1).

Table 15

ANOVA Within-Subjects Contrast between RCFT-SF Copy vs Immediate trials for the Control (N =87) and SF-group (N = 36)

Subscale	SS	*df*	MS	*F*	*p*	Partial Eta Squared
RCFT-SF – Copy vs. Immediate	1626.48	1	1626.48	13.37	.001	.099

Figure 1


RCFT-SF Scores on Copy vs. Immediate Trials
Estimated Marginal Means
46.0
45.0
44.0
43.0
42.0
41.0
40.0
39.0
38.0
37.0
36.0
35.0
34.0
Copy
Immediate
Control
SF-group

CHAPTER 5: DISCUSSION

As the number of older adults in the general population continues to grow, it is increasingly important for neuropsychological evaluations to consider utilizing brief measures that are adequately sensitive for identifying changes in cognitive functioning and help decrease the negative impact of both physical and mental fatigue for older individuals (Banerjee et al., 2020; Jorm & Jolley, 1998; Kramer et al., 2020; Negash et al., 2011; Ortman, Velkoff, & Hogan, 2014). Therefore, it is vital for neuropsychological evaluations to implement standardized and evidenced-based assessment practices that improve the quality of evaluations for older adults (Hunsley & Mash, 2007; Knight, 2004; Vacha-Haase, 2013). Thus, the primary objective of this research study was to identify if the RCFT-SF produced results consistent with the standard RCFT administration procedures in accurately in capturing visual memory impairment in the older adult population and examined the impact age as well as anxiety had on visual memory performance.

Interpretations and Implications

The participants used in this study consisted of a highly educated group of individuals from the older adult population that ranged from 65 to 86 years of age and was evenly divided between females (49.2%) and males (50.8%). When evaluating whether the RCFT-SF will identify cognitive impairments in visual memory equivalent to the standard administration procedures scores across the copy, recall, and recognition trials, scores from both the SF-group and control group were compared using independent samples *t*-tests. Results indicated there was no significant difference found between the two measures on the delayed recall trial indicating the shortened delay period (e.g., 10 minutes) used in the RCFT-SF was equivalent to the standard delay period (e.g., 30 minutes) used in the standard RCFT administration procedure. Notably, the

scores obtained from the copy, immediate recall, and recognition trials were not normally distributed and required the use of non-parametric testing to examine the results. While results from the immediate recall and recognition trials did not find a significant difference between the measures, findings from the copy trial indicated there was a significant difference indicating participants in the RFCT group had significantly higher scores than the RCFT-SF group. Finally, participant age was examined to see if there was an effect on scores and results indicated there was a significant difference between the groups, with individuals in the RCFT-SF group being significantly older than those in the RCFT control group. This result suggests that age may have affected the difference in performance on the copy trial between the RCFT-SF group and RCFT control group, which further demonstrates the negative impact that enhanced structural and functional changes associated with aging have on visual memory and visuospatial skills. Ultimately, the results established the RCFT-SF was equivalent to the standard RCFT measure at the delayed recall level and can be substituted in a neuropsychological evaluation to identify visual memory deficits with individuals from the older adult population.

The second hypothesis looked to identify whether higher levels of state and trait anxiety were associated with impaired performance on the RCFT-SF. A series of Pearson correlation analyses were used to examine scores from the immediate recall, delayed recall, and recognition trials. The findings indicated there was no significant relationship between state and trait levels of anxiety on the STAI and a participant's performance on the RCFT-SF. As a result, anxiety was not determined to be related to the participant's ability to recall or recognize aspects of the complex figure. The typical cutoff score to detect clinically significant symptoms of anxiety on the STAI ranges from a *T*-score of 54 on the state scale and 55 on the trait scale for older adults. The mean scores obtained from the participants in this study met criteria on the trait scale (*T*=

56.78) indicating there was the presence of some level of anxiety but did not meet the threshold on the state level (T= 53.70). As a result, though anxiety may have been present during the evaluation it did not seem to play a significant factor in the participants' ability to recall visual information. Furthermore, while participants in this study may have had inherently anxious personalities it appears that their anxiety was not elicited or triggered by the neuropsychological evaluation and their visual recall abilities were not negatively affected by an acute emotional/anxiety response.

For the final hypothesis, it was assessed whether older adults with cognitive impairment had lower scores on the RCFT-SF when compared to those who are unimpaired, which was determined using the participant's OTBM score (impaired < 40; unimpaired ≥ 40). A series of independent samples *t*-tests were conducted and results indicated there was no significant difference found across the delayed and recognition trials for the impaired group as well as for the unimpaired group. These findings indicated that an individual's level of impairment did not impact performance on the RCFT-SF for the delayed and recognition trials. However, a significant difference was identified between the impaired group and unimpaired group, with impaired individuals scoring significantly lower than the unimpaired on the immediate recall trial for the RCFT-SF. This result indicates that impaired individuals had more difficulties in being able to recall aspects of the complex figure during the immediate delay period (3-minutes), which may suggest problems with visual working memory due to decreased activity and structural changes in the frontal lobes, particularly within the prefrontal cortex, that is associated with aging (Gunning-Dixon et al., 1998; Meyer et al., 1994; Oschwald et al., 2020; Raz et al., 1997; Schretlen et al., 2000; Starkstein & Kremer, 2001; van Leijsen et al., 2019).

Finally, the difference between the RCFT-SF group and the control group across the copy and immediate recall trials was examined by a 2 x 2 mixed design ANOVA. The findings indicated the difference found between the RCFT-SF group and the control group was different depending on the copy or immediate recall trial. The largest difference was for the copy trial with the RCFT-SF group performing worse than the control; however, the RCFT-SF group then slightly outperformed the control group during the immediate recall trial. This finding was most likely due to the overall differences between the sample sizes of each group.

It is important to note, the cutoff score for the impaired and unimpaired groups in this study was determined based on a review of the data obtained from the RCFT-SF (e.g., impaired < 40; unimpaired ≥ 40). Additionally, a review to determine the cutoff score using comparison points from the MNB, which determines level of impairment by examining the difference between an individual's OTBM and their estimated level of premorbid functioning, was completed. The MNB groups individuals into three categories based on this variation between their OTBM score and premorbid estimate: mild (1-2 standard deviations lower), moderate (2-3 standard deviations lower), and significant (3 or more standard deviations lower). The most common and frequent *T*-score obtained in neuropsychological testing is 50 and generally even when different metrics are used to evaluate results, scores do not drift too far from the data of a normal distribution in which a *T*-Score of 50 is considered the mean and impairment is 1 standard deviation below. Thus, after reviewing the data, the method used in the MNB to determine level of impairment did not result in a significant difference from the procedures used in this study (e.g., cutoff score of < 40) indicating that both methods resulted in an insufficient number of impaired participants for analysis purposes and denote a valid representation of impairment for participants assessed with the RCFT-SF.

Limitations

A major limitation to this study involved the limited sample size, particularly for the RCFT-SF group. The unequal sample sizes between the SF-group and control group significantly restricted the range of scores creating a lack of diversity and smaller probability of seeing if no differences were evident across all trials on the RCFT. Notably, previous psychometric research for the RCFT has demonstrated strong inter-rater reliability indicating the differences in scores obtained on the two measures is most likely attributable to the unequal number of participants in each group (Kramer & Delis, 1998; Lynch, 1997; Meyers & Meyers, 1995; Plake & Impara, 2001). As a result, the significantly fewer participants in the RCFT-SF created unequal groups and appeared to favor scores that were extreme outliers making it difficult to examine the equivalency between the RCFT-Sf and standard administration.

Additionally, the inclusion of participants from only the older adult population limited the results and made them less generalizable to other individuals of varying ages in the general population. While the primary objective of the study was to examine and establish the efficacy of an abbreviated RCFT for older adults, it would also be important to establish a short-form version of the RCFT to use as an alternative measure in neuropsychological evaluations for the other age groups as well to help create briefer and more cost-effective assessment batteries. The RCFT has been around for over 50 years and various administration procedures across many different settings have been used for evaluating visual memory for various age groups. Also, it has yielded strong internal validity and reliability results for the assessment of visual memory for both young and older adults (Kramer & Delis, 1998; Lezak, 1989; Lynch, 1997; Meyers, & Meyers, 1994; Meyers & Meyers, 1995; Osterrieth, 1944; Plake & Impara, 2001; Rey. 1941).

Another limitation to this study involved the lack of a true experimental design, primarily due to time constraints, in which both versions of the RCFT (e.g., the short-form and standard procedure) would be randomly assigned to a sample of the older adult population and subsequently compared. This would have allowed for a more accurate comparison between the two measures and provide a more effective means of identifying their equivalency. Additionally, it would have potentially established stronger internal validity and reliability for the RCFT-SF as an effective brief measure for older adults.

Finally, anxiety was assessed in this study primarily through the STAI which has shown to be a valid and reliable measure for detecting the presence and severity of current symptoms of anxiety as well as evaluating an individual's propensity to be anxious (Julian, 2011; Spielberger, 1983). One reason why the results may have only shown the presence of anxiety and that it did not seem to mediate performance on the RCFT-SF may have been due to when the administration of the STAI was completed in the battery sequence. Since it was given at the end of the evaluation, participants' may have had more time to manage their initial anxiety and presented with a calmer demeanor limiting the negative effects on performance. Thus, administering the anxiety measure at the beginning or earlier in the evaluation may have elicited a more significant impact of anxiety on the participants' ability to recall visual information on the RCFT-SF. Additionally, general measures often used to assess levels of anxiety are unable to differentiate between its various components even though these can impact performance in different ways. For example, one type of anxiety that is often not accounted for is known as somatic anxiety, which refers to the physiological manifestation of anxiety symptoms (e.g., abdominal discomfort, chest pain, dizziness, headache, etc.), while the more cognitive type of anxiety relates to an individual's specific thought processes associated with their worries

regarding performance and the potential negative consequences (Beaudoin & Desrichard, 2009; Beck et al., 1988; Mella et al., 2020; Morris et al., 1981; Roberts, Hart, & Eastwood, 2016). Although research has shown these different features of anxiety to be correlated at times, different situations and circumstances may elicit one type more than the other which has the tendency to impact and generate different outcomes on individual's performance (Edwards et al., 2017; Mella et al., 2020; Morris et al., 1981).

In the MNB interpretive procedure, the MVP profile reflects a particular pattern seen in score variability in the Attention domain that has been shown (Meyers, 2003; Meyers et al., 2014) to identify whether anxiety has measurably affected the test results. While it is a separate marker from test result profiles indicating other manifestations of anxiety including somatization, somatoform and conversion, it is often seen in these comparison groups as well. The latter diagnoses are manifestations of anxiety that may evade patient's endorsements of anxiety on self-report measures because their experience of the anxiety has been experienced somatically rather than emotionally. However, the MVP was not collected or reviewed in this study which limited the ability to identify the negative impact of anxiety on visual recall performance for the RCFT-SF. Additionally, the pattern analysis outcomes for participants in this study were not reviewed to see if the MNB profiles were similar to individuals with a somatization/conversion disorder which may have been helpful in differentiating which type of anxiety (e.g., somatic vs cognitive) was impacting their performance. While the STAI has been shown to be a solid measure of identifying the more cognitive type of anxiety it may not be the most effective at identifying this type of somaticized anxiety. As such, participants in this study may have been experiencing a more somatic form of anxiety which could have potentially been impacting their performance on the RCFT-SF.

Future Directions

Future research should look towards continuing to explore the development of neuropsychological measures, such as the RCFT-SF, to further establish a unit of standardized and evidenced-based assessment practices to be utilized in brief and comprehensive evaluations for older adults as well as other age groups from the general population (Hunsley & Mash, 2007; Knight, 2004; Kramer et al., 2020; Lezak et al., 2012; Negash et al., 2011; Vacha-Haase, 2013). This will ultimately improve the quality of neuropsychological evaluations not only for older adults by offering patients the appropriate services and provide the most effective care for individuals seeking treatment for neurocognitive impairments (Hunsley & Mash, 2007; Knight, 2004; Kramer et al., 2020; Vacha-Haase, 2013). Additionally, the establishment of a short-form of the RCFT could provide another measure of visual memory that is incorporated into the MNB. The MNB is a comprehensive system used to assess different cognitive domains with the general administration time for completing the full battery typically between two to three hours (Meyers, 2003: Meyers et al., 2014; Meyers & Rohling, 2004; Meyers et al., 2011). As a result, future research could evaluate the utility and efficacy of the short-form RCFT as another visual memory measure for the MNB as well as other neuropsychological assessment batteries. This would conceivably help shorten the overall administration time, decrease the potential interference from fatigue for older adults, and potentially create a more cost-effective means of providing evaluations to those individuals seeking to identify neurocognitive impairments. Additionally, future research may also benefit from examining the pattern analysis outcomes for individuals administered the MNB to see if the profiles of those associated with a somatization/conversion disorder often similar to with those individuals demonstrating memory deficits, particularly within the attention domain. This may help provide neuropsychologists with

the ability to identify the various aspects negatively impacting an individual's performance on the MNB as well as better able to differentiate between memory impairments and those caused by psychosocial factors, such as anxiety.

Conclusion

As previously stated, the number of older adults in the general population is gradually expanding and there is a rising need for neuropsychological measures that are adequately sensitive for detecting significant cognitive changes and functional impairments. This may hopefully help to reduce the experience and impact of physical and mental fatigue as well as enhance treatment care for the aging population. Despite a number of limitations in the current study, that were address above, results did indicate the shortened delay period used in the RCFT-SF was equivalent to the standard delay period for the standard administration procedure. Ultimately, this finding suggests a shorter delay period for the RCFT yields similar results in identifying visual memory deficits whether it be for a 10 or 30 minute delayed condition for older adults and can be utilized to help shorten the overall time of neuropsychological assessments. Furthermore, it helps to establish initial data for the RCFT-SF that can potentially inform future research in creating a valid and reliable measure to utilize in brief, cost-effective neuropsychological evaluations.

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