EVALUATION OF TELEREHABILITATION FOR THE DELIVERY OF REMOTE COGNITIVE REHABILITATION

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Access to specialized cognitive rehabilitation services is often challenging for clients with cognitive disabilities for many reasons. Therefore, the purpose of this study was to determine the efficacy of remote cognitive rehabilitation to provide services to a distant clinic using telerehabilitation (TR). A remote cognitive rehabilitation system was developed to deliver services remotely. The remote cognitive rehabilitation system consisted of two unique components, videoconferencing and a tablet PC equipped with a web-based learning management system (Moodle). The Ecologically Oriented Neurorehabilitation of Memory (EON-MEM) was selected as a manualized approach to delivering cognitive rehabilitation and to standardize administration. The EON-MEM consists of weekly meetings with a clinician, as well as paper based daily homework activities completed between sessions. Electronic versions of the homework were developed and transferred into Moodle. Clinical usability was assessed during development to further refine the system. Upon completion of development, the finalized system was deployed into a clinical trial evaluating the equivalency and efficacy of a 9-week memory intervention delivered face-to-face (FTF) and using TR. Thirty subjects participated in a quasi-experimental study. The findings based upon confidence intervals indicate the TR intervention was not statistically equivalent to the FTF intervention. Efficacy results indicated the overall treatment intervention ($p=0.001$ to 0.055), as well as the FTF group ($p=0.003$ to 0.415) and TR group ($p=0.001$ to 0.070), significantly improved some objective and self-report memory function, including the Wechsler Memory Scale –IV Logical Memory and the Self-Regulation Skills Interview. Participation in the 9-week EON-MEM resulted in statistically and clinically significant improvements in standardized and self-report measures of memory function. Summative usability was conducted on the electronic activities to ensure a high level of fidelity to the original, paper based activities. Additional clinical usability testing was conducted at the conclusion of clinical trial. Usability results indicate subjects were satisfied with completing cognitive rehabilitation sessions remotely, as well as completing homework activities through Moodle on the tablet PC. Results from these studies demonstrate that learning management systems are a novel approach to delivery of cognitive rehabilitation. Results from this preliminary study indicate TR is an acceptable modality for delivering cognitive rehabilitation services.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

PREFACE

I am extremely thankful for all of the support that so many people have provided me. This PhD journey has not been an easy road, but I am lucky to have received encouragement and support from so many wonderful people.

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1.0 INTRODUCTION

Individuals with cognitive disabilities experience a wide range of functional challenges and everyday difficulties resulting from deficits in different cognitive domains. One area where individuals with disabilities may experience a wide range of challenges is in many facets of memory. Due to the heterogeneity of cognitive disabilities, and the range of difficulties a person may experience, cognitive rehabilitation is a means to lessen the impact of these deficits. While cognitive rehabilitation has been shown to reduce the impact of cognitive disabilities, services are still limited for individuals who live in rural or underserved areas. In addition, for individuals who have access to cognitive rehabilitation services, generalizability and utilizing strategies learned during the rehabilitation process do not easily transfer into everyday situations. Telerehabilitation may be a way to lessen the gap in services for individuals with disabilities and to provide services more closely to their natural environment.

2.0 REVIEW OF THE IMPACT AND REHABILITATION OF MEMORY DEFICITS AMONG INDIVIDUALS WITH COGNITIVE DISABILITY

2.1 METHODS

Research studies were identified through electronic database searches. The databases Ovid Medline (1946-2012) the premier medical database, which uses controlled vocabulary Medical Subject Headings, PsychInfo (1967-2012), Cumulative Index to Nursing & Allied Health Literature, Academic Search Premier, and Expanded Academic ASAP, were searched. Keywords and phrases entered included: memory, memory impairment, interventions, rehabilitation, cognitive disability, attention deficit/hyperactivity disorder, traumatic brain injury, acquired brain injury, autism, Asperger's Disorder, pervasive developmental disability, and learning disorder.

The articles included for review included keywords or phrases previously identified in the title or abstract. Additional inclusion criteria were: a) peer reviewed and published in referenced scientific journals or from conference proceedings, b) written in the English language c) published since 2000. Demographic and symptomatology literature that was published more than 15 years ago was still included in the reviews. The reference lists of relevant publications were also reviewed to identify further studies that met the inclusion criteria. Articles were excluded if the study was unrelated to cognitive disabilities (e.g. psychiatric or intellectual disabilities) or cognitive rehabilitation.

2.2 INTRODUCTION

Memory is a complex set of processes with interrelated systems. While the understanding of memory processes has increased, agreement among the definition is still limited. In addition to memory's complexity, difficulties in memory are common among individuals with cognitive disability. In order to better understand deficits in memory, an understanding of the basic components of memory is necessary. The processes of memory have been hypothesized in many ways. Below is one way to organize the different aspects of memory. Additionally, since individuals with cognitive difficulty also experience a wide range of memory deficits, specific cognitive disabilities and memory deficits will also be discussed, as well as general and memory specific rehabilitation interventions.

2.3 MEMORY PROCESSES

There are four major steps in the process of remembering new information: attention, encoding, storage, and retrieval (Sohlberg and Mateer, 2001). Attention is an initial stage, or a necessary prerequisite, of memory that includes alertness and arousal and there are different levels of attention. Attention, at its most basic level, includes simple alertness and arousal. At a higher level, attention includes working memory, sustained attention, selective attention, and alternating and divided attention (Haskins, Cicerone, Dams-O'Connor, Eberle, Langenbahn, & Shaprio-Rosenbaum, 2012). Sustained attention is maintaining concentration over time, selective attention is the ability to resist interference, and alternating and divided attention is being able to allocate additional resources. Attention is a critical key component in memory because it allows individuals to utilize incoming information (Sohlberg & Mateer, 2001). Decreased alertness, arousal, and sustained attention have been associated with memory impairments (Sohlberg and Mateer, 2001).

Encoding in also an initial stage of memory and consists of continued analyses of the incoming information to be remembered. It is also the process of assigning meaningfulness to verbal or nonverbal sensory information, so it can be recalled later. Information that is deeply processed will have a higher likelihood of being recalled, opposed to information that is shallowly processed (Craik & Lockhart, 1972). Storage of memory refers to the transfer of a temporary memory to a form or location in the brain for permanent maintenance or later access. Retrieval of memory refers to the searching for existing memory traces, and it requires monitoring the accuracy and appropriateness of memories pulled from storage (Sohlberg & Mateer, 2001). Retrieval is usually linked to frontal lobe contributions of memory ability. Frontal lobe structures are involved in strategy formation, memory for temporal order, self-monitoring, and initiating retrieval. Retrieval problems are known to be related to faulty organization of information at the time of encoding. Figure 1 displays the four steps in the memory process.

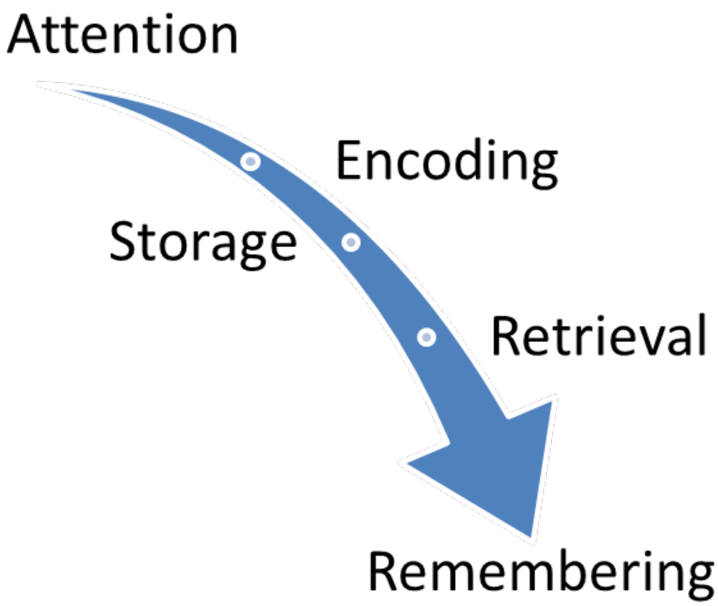

Figure 1. Memory Process

2.4 TYPES OF MEMORY

There are several types of memory and they can generally be broken down into time-dependent, content-dependent, and everyday forms of memory. Table 1 displays a summary and definition of the different types of memory.

2.4.1 Time-Dependent Forms of Memory

Short-term memory is the storage of a limited amount of information, for a restricted period of time. Information remains in short-term memory for only a few minutes and at a very limited capacity (Sohlberg and Mateer, 2001). The average individual can hold approximately 3-5 items in short-term memory and for just a few seconds so it can be encoded and stored in long-term memory (Sohlberg and Mateer, 2001; Haskins et al., 2012).

Working memory is the set of processes that permits us to hold on to information until it is utilized or encoded, or to actively hold information needed to complete complex tasks (Sohlberg & Mateer, 2001). Working memory is a critical component to conscious thought because it allows an individual to internally represent information, such as rules, and helps to guide the decision making process and responses during an activity so that the response is not dominated by the immediate sensory cues within the environment (Martinussen, Hayde, Hogg-Johnson, & Tannock, 2005).

Long-term memory involves the encoding and storing of information in the short-term (Haskins, et al., 2012). Long-term memory is unlimited memory, with no decay, and holds information in a permanent store with an unlimited capacity (Sohlberg and Mateer, 2001). Once it's stored in long-term memory, it can be retrieved (Haskins et al., 2012).

2.4.2 Content-Dependent Forms of Memory

Long-term memory can be further distinguished into either declarative memory or nondeclarative memory, depending upon the type of information that is processed. Declarative memory refers to a person's explicit knowledge base and is information that is purposefully learned, stored and retrieved.

Declarative memory is generally the memory type that is generally meant by the umbrella term of memory (Milner, Squire, & Kandel, 1998). Declarative memory can also be further subcategorized into semantic and episodic memory. Semantic memory refers to a broad domain of cognitive information acquired about the world. This information includes word meanings, classes of information, facts and abstract concepts or ideas. This type of information is learned and the person knows, but may have limited recollection of when or where it was learned (Tulving, 1972). Episodic memories are context-specific memories of things that have happened in a time and place. These memories are events that one has experienced (Sohlberg and Mateer, 2001).

Nondeclarative memory is a type of memory that does not rely on conscious recall, but rather implicit learning. Procedural memory is also a form of nondeclarative memory and is often involved in learning motor skills. Priming is another method of implicit learning that provided increased chance of retrieval when a person is previously exposed to information without explicit learning. Priming is a phenomenon that cues can prompt accurate recall without an individual's even being aware of, or recalling, that the information was previously presented. Stem completion activities are the classic priming examples (Sohlberg and Mateer, 2001).

2.4.3 Everyday Memory

Prospective memory is the memory for events that will happen in the future, such as remembering to attend your doctor's appointment the following week or your meeting at a specific time. Prospective memory is not a type of memory, but rather a set of processes including metaknowledge, planning, monitoring, content recall, and output monitoring (Dobbs & Reeves, 1996).

Metamemory is a person's understanding of their own memory functioning. At is most fundamental level, metamemory is a person's self-awareness of their memory, and learning strengths and weaknesses. This understanding in turn influences the person's behavior.

Individuals who have impairments in metamemory will lack self-awareness of the extent of, or the nature of, their memory problems (Sohlberg and Mateer, 2001).

Table 1. Types of Memory

Form of Memory	Memory Type	Definition
Time Dependent Forms of Memory	Short-term memory (working memory)	The storage of limited information (3-5 items) for a restricted period of time (up to a few minutes)
	Long-term memory	Unlimited memory with no decay
Content Dependent Forms of Memory	**Declarative memory**	Explicit knowledge base
	Episodic memory	Storage of events that are tagged in time and place
	Semantic memory	Storage of facts
	Nondeclarative memory	Implicit memory; does not require episodic memory
	Procedural memory	Acquisition of perceptuomotor skills and the learning of rules and sequences
	Priming	Increased chance of retrieval when previously exposed to information without explicit learning
Everyday Memory	Prospective memory	Remembering to carry out intentions
	Metamemory	Awareness about one's own memory functioning

Note: Adapted from Sohlberg and Mateer (2001)

2.5 BADDELEY'S MODEL OF WORKING MEMORY

Working memory is a complex process that has implications for remembering all types of information. If input that is received is not encoded during the short-term manipulation, it will not be properly stored in the long-term, and therefore result in significant memory challenges. In order to better understand the memory processes, Baddeley and Hitch (1994) re-described a multicomponent concept of working memory they originally introduced in 1974. Their approach looks at the fractionation of working memory into three subcomponents: the phonological loop, the visuospatial sketchpad, and the central executive (Baddeley, 1986; Baddeley & Hitch, 1994). According to Baddeley and Hitch (1994), the phonological loop is the simplest component, and has also been the most extensively researched. The phonological loop is the subsystem that holds and manipulates speech based information, or in some cases, also verbal stimuli. The phonological loop can also processes visual stimuli and register it into the phonological store (Baddeley & Hitch, 1994). Research has found that words that are similar in sound are difficult to recall, irrelevant verbal stimuli can impair a person's ability to recall important details, and an increase in the amount of information to be remembered significantly decreases the immediate memory span (Baddeley & Hitch, 1994; Conrad & Hull, 1964; Colle & Welsh, 1976; Baddeley, Thomson, & Buchanan, 1975).

While visual information can be processed through the phonological loop, the visuospatial sketchpad is vital to define visual working memory as visual imagery and visual perception utilize systems that are not used with verbal information (Baddeley & Hitch, 1994). Similar to the phonological loop, the visuospatial sketchpad holds and manipulates visual and spatial based information. The visuospatial sketchpad has proven more challenging to research as visual and spatial information are processed through separate, yet interacting components (Baddeley, 1986; Farrah, 1988).

The central executive is the most complex part of this model of working memory and is hypothesized as being responsible for attention control with respect to working memory (Baddeley, 1996). The central executive is responsible for coordinating the phonological loop and the visuospatial sketchpad (Baddeley & Hitch, 1994). The central executive component is assumed to be responsible for the control and manipulation of the stored information in addition to acting upon information pulled from long-term memory (Martinussen et al., 2005; Baddeley,

1996) and is responsible for complex cognitive activities such as text generation, language and reading comprehension, and mental calculation (Martinussen et al., 2005; Baddeley, Gathercole, & Papagno, 1998)

It is important to note that many reviews of working memory in persons with cognitive disability evaluates components of working memory through Baddeley's working memory model. According to Martinussen, Hayden, Hogg-Johnson, and Tannock (2005), research presenting results from the evaluation of working memory in adults with attention deficit hyperactivity disorder may present inconsistencies due to the presentation modality, verbal or spatial, or the processing requirements, storage or storage and manipulation. Individuals with cognitive disability may also present with working memory deficits and these challenges may be more or less severe when storing and manipulating either verbal or visual and spatial information.

2.6 MEMORY AND COGNITIVE DISABILITY

According to the 2011 Unites States Disability Status Report, published through the Employment and Disability Institute at Cornell University, the prevalence rate of disability in the United States was 12.1% for individuals of all ages. More specifically, 4.9% of the United States population had a cognitive disability (Erickson, Lee, & von Schrader, 2012). Individuals with cognitive disorders may experience difficulty with short-term, long-term, or working memory. While the focus of this project is adults with cognitive disability, studies examining the impact of memory in adults were limited. As a result, several studies reviewed examined the impact of memory in children, as it is hypothesized that deficits in children will continue into adulthood. If an individual has difficulty with short term-memory, it will subsequently impact their long-term and their working memory abilities. Additionally, individuals may have intact semantic memory (memory of facts), but may experience difficulty with procedures or with life experiences.

2.6.1 Acquired and Traumatic Brain Injury

Acquired brain injury (ABI) includes traumatic brain injury (TBI), stroke, brain illness, and any other kind of brain injury acquired after birth. ABIs however, do not include degenerative brain conditions such as dementia (e.g., Alzheimer's disease) or Parkinson's disease.

Each year, approximately between 1.4 and 1.7 million people in the United States sustain a traumatic brain injury, and the population with increased risk for TBI is males between the ages of 15 and 19 years (Langlois, Rutland-Brown, & Wald 2006; Faul, Xu, Wald, & Coronado, 2010). It is also estimated there are over 5.3 million people living with TBI-related disabilities across the United States (Langlois, Rutland-Brown, & Wald 2006). The Centers for Disease Control and Prevention (CDC) also report that the most common causes of TBI include falls (35%), motor vehicle accidents (17%), struck-by or – against incidents (16%), and assaults (10%) (Faul, et al., 2010). Sports and recreation activities are also a leading cause of concussions, with estimated annual rates between 1.6 million to 3.8 million sports-related TBIs, including injuries that do not receive medical attention (Langlois et al., 2006). TBI can result in a vast array of cognitive deficits because TBI can affect any part of the brain. Common cognitive dysfunctions following TBI include difficulties with memory, attention, language, concentration and attention, visuospatial perception, sensory-motor integration, affect recognition, communication, speed of processing, and executive function (Levine, 1988;

Borgaro, Prigatano, Kwasnica, & Rexer, 2003; Halbauer, Ashford, Zietzer, Adamson, Lew, & Yesavage, 2009

Since many of the components necessary for encoding and memory are impaired in individuals with TBI, it is no surprise why memory deficits are frequently seen. For individuals with brain injury, memory deficits are one of the most persistent and pervasive impairments (Parente & DiCesare, 1991). Individuals with TBI have difficulties with attention and processing speed, which may lead to significant deficits in prospective memory (Groot, Wilson, Evans, & Watson, 2002; Kinch & McDonald, 2001), working memory (McDowell, Whyte, & D'Esposito, 1997), and short-term memory (Levin, Goldstein, High, & Eisenberg, 1988) which in turn affects long-term memory. After brain injury, individuals may also experience changes in their everyday memory ability (Sohlberg & Mateer, 2001). Memory impairments are one of the most frequent sequelae following brain injury, with approximately 69% to 80% of individuals reporting memory deficits (Thomsen, 1987; Brooks, Campsie, Symington, Beattie, & McKinlay, 1986). Additionally, longitudinal studies suggest a limited decrease in the severity or frequency of memory deficits five years after TBI (McKinlay, Brooks, Bond, Martinage, & Marshall, 1981; Thickpenny-Davis & Barker-Collo, 2007).

2.6.2 Attention Deficit Hyperactivity Disorder

Attention deficit/hyperactivity disorder (ADHD) is a prevalent disorder diagnosed in children, but frequently persists into adolescences and adulthood (Barkley, 2006). The essential features of ADHD are a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequently displayed and more severe than is typically observed. Individuals with ADHD may also have low frustration tolerance, temper outbursts, bossiness, stubbornness, excessive and frequent insistence that requests be met, mood lability, demoralization, dysphoria, rejection by peers, and poor self-esteem (American Psychiatric Association (APA), 2000).

According to the APA (2000), the prevalence rate of ADHD in school aged children is estimated between 3%-7%. The data on prevalence rates in adults is limited, but some estimates state that ADHD persists into adulthood at a rate of 30%-50%, for those who were diagnosed as children (Weiss & Hechtman, 1993). Kessler, Adler, Barkley, Biederman, Conners, Demler et al. (2006) reported the clinician rated diagnoses of ADHD in a sample of almost 10,000 adults was 4.4%.

Individuals with ADHD often present with significant deficits in memory functioning. According to the APA, being forgetful in daily activities is one of the nine diagnostic criteria under the inattention symptoms (APA, 2000). According to Quinlan and Brown (2003), individuals with ADHD often self-report having good long-term memory, but have significantly impaired short-term memory. Due to difficulties with inattention, individuals with ADHD often present clinically with impairments in working memory. Functionally, these individuals have difficulty remembering something they want to say while others are still speaking, as well as remembering what they have just read or have just been told (Quinlan & Brown, 203). Additionally, Martinussen, Hayde, Hogg-Johnson, and Tannock (2005) conducted a meta-analysis on 26 research studies to determine the evidence for working memory deficits for children with ADHD. Results indicate individuals with ADHD exhibit deficits in spatial storage and spatial central executive components of working memory (Martinussen et al., 2005).

In addition to deficits in working memory, individuals with ADHD also have difficulty with short-term verbal memory have been found to be impaired on standardized measures such as the California Verbal Learning Test (CVLT) (Seidman, Biederman, Weber, Hatch, & Faraone, 1998). Individuals with ADHD often present with difficulty in working memory (Martinussen, et al., 2005).

2.6.3 Specific Learning Disorder

Learning disorders, or learning disabilities, are diagnosed when the individual's achievement on individually administered, standardized tests in reading, mathematics, or written expression is substantially below that expected for age, schooling, and level of intelligence. This cognitive disability includes reading disorder, mathematics disorder, disorder of written expression, or learning disorder not otherwise specified. Specific learning disabilities (SLD) may be associated with cognitive processing difficulties, for example, deficits in attention, memory, linguistic processing, that often proceed, or are associated with, learning disorders. Individuals with SLD may have deficits in one or more of the following areas: attention, reasoning, processing, memory, communication, reading, writing, spelling, calculation, coordination, social competency, and emotional maturity (APA, 2000).

Depending on the definitions of learning disability or learning disorder used, and the nature of the assessment, approximately 2% to 10% have been diagnosed with a learning disorder. Additionally, an estimated 5% of the public school population in the United States has been diagnosed with a learning disability (APA, 2000). Learning disorders are life long and continue to present challenges well into adulthood. McGrother, Thorp, Taub, and Machado (2001) found the prevalence of learning disorders in adults has increased 1% annually over the last 35 years. Young, Beitchman, Johnson, Douglas, Atkinson, Escobar et al. (2002) state that while lower level processing skills such as phonological awareness can impact academic performance in adults, higher level skills such as working memory and executive functions are necessary for academic post-secondary skills.

SLDs also result in significant impairments to memory (Schuchardt, Maehler, & Hasselhorn, 2008). According to Alloway and Gathercole (2006) and Pickering (2006a), learning disorders are associated with significant impairments in working memory. Research has found that children with reading disabilities present with deficits in the phonological processing and storage components of working memory (Pickering, 2006b; Swanson, 2006) as well as central executive functioning (Landerl, Beva, & Butterworth, 2004) and visual-spatial working memory (Pickering, 2006b). Children with mathematical or arithmetic learning disorders also have deficits in the domains of phonological processing and storage, central executive functioning, and visual-spatial working memory (Passolunghi, 2006). Individuals with learning disabilities may also experience difficulty with aspects of memory. Henry (2001) evaluated working memory for 11-12 year old children with borderline, mild, and moderate learning disabilities. All participants were given subtests from the British Ability Scales II, as well as the Test of Learning and Memory. Results indicated from this evaluation study, children with mild and moderate learning disabilities were impaired on all measures of working memory compared to children of average abilities. Children with borderline learning disabilities performed relative to non-learning disabled children on visuospatial and complex scan tasks, however displayed impairments in phonological span tasks. Results suggest that working memory is significantly lower in children with mild and moderate learning disabilities and slightly lower in children with borderline learning disabilities (Henry, 2001).

2.6.4 Autism Spectrum Disorders

Autism spectrum disorders (ASDs) are characterized by severe and pervasive impairment in several areas of development: reciprocal social interaction skills, communication skills, or the presence of stereotyped behavior, interests, and activities and are distinctly deviant from the person's developmental level or mental age.

The Diagnostic and Statistical Manual–IV–Text Revision (DSM-IV-TR) describe the essential features of ASDs are the presence of markedly abnormal or impaired development in social interaction and communication and a markedly restricted repertoire of activity and interests (APA, 2000). Individuals with autism may also have impairments in nonverbal behaviors, such as eye-to-eye contact, facial expressions, body postures and gestures, to regulate social interaction and communication. Some individuals with autism have no interest in establishing friendships with others, while some may desire friendships, but have limited understanding of social interactions. Additionally, individuals with autism may have limited awareness of others and may be oblivious to other children, may have no concept of the needs of others, or may not notice another person's distress. With respect to the restricted repertoire of activity and interests, individuals may be preoccupied by one or more stereotyped and restricted pattern of interest that is abnormal in intensity or focus; be inflexible in the adherence to specific, nonfunctional routines or rituals; or stereotyped and repetitive motor mannerisms (APA, 2000).

The prevalence rate of autism in epidemiological studies reports a median rate of 5 cases per 10,000, with reported rates ranging from 2 to 20 cases per 10,000 individuals. According to the CDC, in 2009, the prevalence of parent-reported diagnosis of ASD to be roughly 1 in 91 among US children aged 3 to 17 years (APA, 2000).

Similar to Autistic Disorder, the essential features of Asperger's Disorder are severe and sustained impairments in social interaction and the development of restricted, repetitive patterns of behavior, interests, and activities. Asperger's Disorder differs from autism in that; there are no clinically significant delays or deviance in language acquisition, although more subtle aspects of social communication may be affected. With respect to social interactions, individuals manifest difficulties by an eccentric and one-sided social approach to others such as pursuing a conversational topic regardless of others' reactions, rather than social and emotional indifference (APA, 2000). The prevalence rate for Asperger's Disorder is not well defined, however, recent studies have estimated the prevalence rate for Asperger's to range from 0.3 – 48.4 per 10,000, and varied greatly due to methodological differences between research studies (APA, 2000; Sponheim & Skjeldal, 1998; Kadesjö, Gillberg, & Hagberg, 1999; Fombonne, 2003). Other diagnoses included in the autism spectrum include pervasive developmental disability.

Additionally, it has been found that individuals with ASD experience everyday memory difficulties, including areas of prospective memory, word recall and the ability to remember basic instructions and routes between places the individual frequently visits (Jones, Happé, Pickles, Marsden, Tregay, Baird, et al., 2011). Goldberg, Mostowsky, Cutting, Mahone, Astor, Denckla, et al. (2005) found that children with both ADHD and with an autism spectrum disorder diagnosis have impairments in working memory compared to healthy controls. Episodic memory and autobiographical memory are also impaired in individuals with an ASD diagnosis. Millward, Powell, Messer, and Jordan (2000) examined episodic memory deficits in children with an ASD diagnosis and found this group has significant difficulty in processing, and therefore remembering, personally experienced events. It is hypothesized that episodic memory deficits may be a result of difficulty encoding material for storage and long-term retention (Bowler, Gardiner, & Grice, 2000; Crane & Goddard, 2008).

2.6.5 Other Neurodevelopmental and Neurological Disorders

In addition to the cognitive disabilities detailed above, several other neurodevelopmental and neurological disorders can result in cognitive impairments. Mild cognitive impairment is a disorder that is characterized by a cognitive decline greater than what is expected for a person's age and their level of education. Mild cognitive impairment often includes significant impairments in memory, but does not interfere with activities of daily living (Gauthier, Reisberg, Zaudig, Petersen, Ritchie, Broich, et al., 2006). Additional neurodevelopmental and neurological disorders include epilepsy, cancer, dementia, spina bifida, and cerebral palsy.

2.6.6 Impact of Memory Deficits in Cognitive Disability

Individuals who have memory disorders may experience difficulties in learning and retaining new information. However, prospective memory often presents as the most problematic memory impairment, which is the process of remembering to remember information. This usually results in forgotten and missed appointments, as well as missed deadlines.

As a result of these difficulties, individuals with cognitive disability experience lower education levels and may be unemployed, or underemployed. The school drop-out rate for children/adolescents with learning disabilities is nearly 40%, or 1.5 times the national average. Additionally, adults with learning disabilities tend to live at home longer than their peers and are often unemployed, underemployed, or poorly paid (APA, 2000). On average, individuals with ADHD obtain less schooling than their peers and have poorer vocational achievement (APA, 2000). The unemployment rate of individuals who have sustained a TBI ranges from 12-70%, depending on the employment definition, and may include sheltered and supported employment (Shames, Treger, Ring, & Giaquinto, 2007). The full-time employment rate for individuals without disabilities is approximately 60%, while the same rate for individuals with cognitive disabilities is roughly 14% (Erickson et al., 2010). Further, the 2011 Unites States Disability Status Report states the employment rate for individuals with cognitive disabilities at 23.0%, while the rate for individuals without disabilities is 75.6% (Erickson et al., 2012).

2.7 SPECIFIC MEMORY IMPAIRMENT

There are different types of memory impairments an individual can experience. A common form of memory impairment includes amnesia, which simply defined, is the loss of memory. Anterograde memory impairments include inability to acquire new information following brain injury or after a certain date, while retrograde memory impairments is the inability to retrieve information stored prior to brain injuries (Sohlberg and Mateer, 2001). Posttraumatic amnesia is a period of confusion, with inability to remember events moment to moment, usually following decreased consciousness (Sohlberg and Mateer, 2001). Individuals may also experience greater difficulty remembering verbal or nonverbal information. Additionally, an individual may experience difficulty with any of the memory types previously mentioned. Prospective memory impairments often cause the most functional problems for individuals (Winograd, 1988; Fleming, Shum, Strong, & Lightbody, 2005). Impairments in prospective memory have the potential to limit functional independence, including the ability to carry our activities and instrumental activities of daily living, successfully completing academic requirements, or the ability to find and maintain gainful employment (Winograd, 1988; Fleming et al., 2005).

2.8 COGNITIVE REHABILITATION

The Commission on Accreditation of Rehabilitation Facilities and the National Academy of Neuropsychology has adopted the definition of cognitive rehabilitation presented by Berquist & Malec (1997) that states cognitive rehabilitation is a systematic, functionally oriented service of therapeutic cognitive activities and an understanding of the person's behavioral deficits. Functional changes are achieved by directing cognitive rehabilitation services to reinforce, strengthen or reestablish previously learned patterns of behavior, or by establishing new patterns of cognitive activity or mechanisms to compensate for impaired neurological systems. A major goal of cognitive rehabilitation is to provide interventions that lessen the cognitive impairment itself, or to lessen the disabling effect of the cognitive impairments (Committee on Cognitive Rehabilitation Therapy for Traumatic Brain Injury, 2011a). Schutz and Trainor (2007) further define cognitive rehabilitation as a systematic, theory-based program of integrated didactic, experiential, procedural, and psychosocial training activities conducted to restore cognitively compromised adaptation. These activities are conducted to increase interpersonal and vocational participation, self-awareness, and self-determination. The goal of cognitive rehabilitation is to maximize cognitive functioning though the implementation of various theoretically based and empirically validated interventions. Ultimately, by maximizing cognitive functioning, cognitive rehabilitation aims to minimize the functional consequences of post-TBI cognitive and behavioral impairments (Dams-O'Connor & Gordon, 2010).

Cognitive rehabilitation gained popularity in the United States after World Wars I and II to treat injured service members and focused on compensatory and restorative cognitive rehabilitation, and has now become a fundamental component of TBI rehabilitation (Boake, 1989; Parente & Herrmann, 1996).

2.8.1 Roles of Cognitive Rehabilitation

Cognitive rehabilitation interventions are provided to rehabilitate thinking skills such as memory, attention, and planning and problem solving (Committee on Cognitive Rehabilitation Therapy for Traumatic Brain Injury, 2011b). In addition to remediating these thinking skills, there are several roles cognitive rehabilitation plays in the rehabilitation of individuals with cognitive disability. First, for individuals with TBI and other brain injuries, the first role is to restore function by restoring the neural circuitry underlying impaired cognitive processes. This is achieved through practice and focused training exercises that promote systematic engagement to re-establish the neural circuits (Dams-O'Connor & Gordon, 2010). The second role is compensatory strategy training. Ultimately, the goal of cognitive rehabilitation is to aid individuals with cognitive difficulties through compensation of impaired functions in the use of learned internal or external strategies. Another role of cognitive rehabilitation is to increase self-awareness since lack of insight or awareness has been identified as a barrier to successful treatment (Dams-O'Connor & Gordon, 2010; Ownsworth, McFarland, & Young, 2002). Interventions designed to increase self-awareness have demonstrated the ability to also have a significant impact on self-appraisal, appropriate goal setting, and error monitoring (Ownsworth, McFarland, & Young, 2000; Goverover, Johnston, Toglia, & Deluca, 2007). Additional cognitive rehabilitation roles include improving mood and regulating emotions through cognitive behavioral therapy interventions, facilitate return to work after injury or take the necessary steps to obtain a job, increase community integration including social integration and participation, and finally the prevention of self-injurious and antisocial behavior (Dams-O'Connor & Gordon, 2010). In order to achieve the goals of cognitive rehabilitation, the American Congress on Rehabilitation Medicine (ACRM) suggests a stepwise process for delivering cognitive rehabilitation. The first steps include problem orientation, awareness, and goal setting. Once goals are formulated, the next steps consist of compensation, internalization, and generalization (Haskins, Cicerone, Dams-O'Connor, Eberle, Langenbahn, & Shaprio-Rosenbaum, 2012).

The ACRM defines the goal of cognitive rehabilitation as a process to maximize client safety, daily functioning, independence, and quality of life and suggests that cognitive rehabilitation occurs through three stages. The first stage in cognitive rehabilitation is the acquisition stage in which the client is taught different features of the treatment strategy. Once the client has learned the purpose and procedures of a particular treatment, the client then moves to the application stage. The application stage consists of the client applying strategies to simple tasks within the context of their rehabilitation sessions, which includes practicing the strategies using clinical activities. The client is encouraged to use both internal and external strategies. Internal strategies include self-generated activities or thoughts that aim to enhance conscious control over one's thoughts, emotions, or behaviors. External strategies are defined as strategies outside of the client and include things like diaries or logs, calendars, Post-it® notes, or complex cognitive assistive technology and smart phones (Sohlberg & Mateer, 2001). The strategies are utilized in the therapy sessions so the rehabilitation specialist can provide assistance and cues for appropriate use. As the client become more proficient with the strategy, support cues are gradually decreased. Once the strategies have been successfully demonstrated in the rehabilitation sessions, the client attempts to apply the strategies to everyday situations outside of the clinic. Table 2 displays a breakdown of the stages of cognitive rehabilitation, as presented by Sohlberg and Mateer (2001).

Table 2. Treatment Goals and Strategies Associated with Stages of Cognitive Rehabilitation

Stage of Treatment	**Goals**	**Types of Strategies Used**
Acquisition	1. Teach purpose and procedures of treatment model 2. Help patient recognize and accept deficits and benefits of treatment	1. External 2. External
Application	1. Improve effectiveness and independence in compensating for deficits 2. Promote internalization of strategies	1. External 2. Internal
Adaptation	1. Promote transfer of training to tasks including those that are less structured, more novel, complex, and/or distracting 2. Promote generalization of skills from the structured therapy setting to less structured environments such as home, community, and work	1. External and Internal 2. External and Internal

*Adapted from ACRM Manual (Haskins, et al., 2012)

Because the sequale of TBI and the functional limitations of other cognitive disabilities impact more than one functional domain, cognitive rehabilitation must include multidisciplinary teams to incorporate remedial strategies into all therapeutic encounters over multiple cognitive domains. Cognitive rehabilitation is sometimes provided through a comprehensive-holistic approach with the goal to address multiple cognitive deficits and may also incorporate psychological interventions to address limitations in emotional, motivational, and interpersonal functioning (Gordon, Zafonte, Cicerone, Cantor, Brown, Lombard, et al., 2006). Generally, cognitive rehabilitation is offered either to restore or to compensate for cognitive deficits, and programs are designed to address one of these approaches. Restorative cognitive rehabilitation is designed and implemented to improve the individual's core cognitive abilities and to regain lost function through repetitive exercise, while the goal of compensatory cognitive rehabilitation is to develop appropriate strategies to make up for impaired skills and abilities (National Institutes of Health Consensus Statement, 1998; Ylvisaker & Szekeres, 1998). While many have attempted to define cognitive rehabilitation as mutually exclusive approaches, restorative and compensatory cognitive rehabilitation are not used independently in practice (Ylvisaker & Szekeres, 1998). Additionally, attempts have been made to focus on domain specific rehabilitation, as opposed to integrated perspectives. However, most cognitive rehabilitation interventions are designed to target several aspects of cognition. As a result, it is relatively uncommon for interventions to focus exclusively on one cognitive domain without directly or indirectly addressing difficulties in another (Dams-O'Connor & Gordon, 2010).

2.8.2 Use of Technology in Cognitive Rehabilitation

Within cognitive rehabilitation, technology use has increased as access to devices has improved. While the number of interventions utilizing technology continues to increase, technological interventions can vary in their application within rehabilitation. The use of computers in cognitive rehabilitation began in the 1970s and has gained popularity as designs have become more sophisticated. Cognitive rehabilitation can vary from computer assisted and computer aided cognitive rehabilitation to computer based cognitive remediation training, depending upon the level of dependence on the computer applications and the involvement of a rehabilitation specialist. In addition to meeting regularly with a rehabilitation specialist, computer assisted interventions provide several advantages in cognitive rehabilitation because they provide the opportunity for presentation of higher level stimuli in a standardized format that may help engage clients, allow for more accurate, objective measure of client progress on activities, and has the ability to present activities to a client based upon the current level of functioning (McGuire, 1990; Tam & Man, 2004).

Computer assisted or computer aided cognitive retraining has gained popularity as the design of video games and home computers has increased. While recreational activities such as puzzles and games were often used in rehabilitation programs, the increased ease of access and decreased cost of small home personal computers provided an opportunity to use these devices to provide rehabilitation for cognitive deficits (Lynch, 1987; Lynch, 1982; Lynch, 2002). Educational software and cognitive rehabilitation programs were created and used within the rehabilitation of cognitive deficits. Educational software such as *Where in the World is Carmen San Diego* is an example of a complex educational computer game that can be used within cognitive rehabilitation (Lynch, 2002). During the 1970s and early 1980s, clinicians began developing software specifically for the remediation of attention and memory (Lynch, 1986; Lynch, 2002). These early specific computer programs tended to be plain, slow, and lacked ecological validity (Lynch, 1992; McKittrick, Friedman, Pearman, & Yesavage, 1997; Lynch, 2002). While computer assisted cognitive retraining utilizes computer programs in the therapy of cognitive deficits, computer based cognitive remediation training are more comprehensive self-paced programs that a person can complete independently. Additionally, computer based cognitive rehabilitation programs suggest the ability to provide treatment at a level equivalent to or better than that of more traditional cognitive rehabilitation intervention, although empirical support is still limited (Gontkovsky, McDonald, Clark, & Ruwe, 2002; Cicerone, Dahlberg, Kalmar, Langenbahn, Malec, Bergquist, et al., 2000; Cicerone, Dahlberg, Malec, Langenbahn, Felicetti, Kneipp, et al., 2005).

While older systems lacked sophistication, advances in technology have greatly improved the complexity of these computer based training programs. Older versions of computer based programs resulted in task specific outcomes that lacked generalizability, however advancements in the sophistication of these training programs has also lead to an increase in the transferring of skills learned through these programs past the rehabilitation setting (Hertzog, Kramer, Wilson, & Lindenberger, 2008). Additionally, these programs approach the remediation of cognitive deficits from a brain plasticity-based cognitive training (BPCT) model and are intended to serve as a sort-of exercise program for the brain (Mahncke, Bronstone, Merzenich, 2006; Posit Science, 2013). In addition the advances in technology, commercialization of these programs has increased the availability to community dwelling individuals who may not seek out traditional cognitive rehabilitation programs. One example in the improvements of these programs can be demonstrated through the visual processing speed program originally developed by Ball and Roenker (Roenker, Cissell, Ball, Wadley, & Edwards, 2003; Ball, Edwards, & Ross, 2007). This program was acquired by Posit Science Corporation (San Francisco, California) in 2007. Upon acquiring the rights, Posit Science maintained the original tasks and rehabilitation content, however the delivery system was modified and gaming elements were added to increase the usability, allow for self-administration, and to lengthen engagement time. The new program was also renamed to *Road Tour* (Wolinsky, Vander Weg, Howren, Jones, Martin, Luger, et al., 2011). *Road Tour* became commercially available in 2007 as part of Posit Science's *Insight* program (Wolinsky et al., 2011).

Additional programs such as the Advanced Cognitive Training for Vital Elderly (ACTIVE; Jobe, Smith, Ball, Tennstedt, Marsiske, Willis, et al., 2001; Wolinsky, Unverzagt, Smith, Jones, Wright, & Tennstedt, 2006; Wolinsky, Mahncke, Kosinksi, Unverzagt, Jones, et al., 2009; Lebowitz, Dams-O'Connor, & Cantor, 2012) and Improvement in Memory with Plasticity-Based Adaptive Cognitive Training (IMPACT; Smith, Housen, Yaffe, Ruff, Kennison, Mahncke, et al., 2009) have also been proven to effective in improving objective neuropsychological outcomes, as well as self-repot measures of cognitive functioning. Lebowitz, Dams-O'Connor, and Cantor (2012) conducted a study to evaluate the feasibility of using a commercially available BPCT program. Results indicated that 10 individuals with TBI were able to use this software in their homes with few technical problems and participants reported subjective improvements in cognitive functioning. More recently, the BrainHQ is a brain fitness program that aims to improve memory, attention, and people skills through drills and activities that combines the previous BPCT programs and is now web-based as opposed to previous versions that were available through software downloads (Posit Science, 2013).

While research has found computer based cognitive rehabilitation programs to be effective, for individuals with significant cognitive impairments, these programs should be used in conjunction with cognitive rehabilitation sessions with clinicians to reinforce strategies between sessions. Lebowitz et al. (2012) further state in their feasibility results that BPCT could be a possible intervention for individuals with TBI, as an add-on to comprehensive cognitive rehabilitation.

As cognitive rehabilitation has made advancements, the rehabilitation field in general has also made significant advances in serving individuals with TBI due to assistive technology. In the past, individuals without cognitive disability used assistive technology for cognition to further increase their abilities (Gillespie, Best, & O'Neill, 2012), however, these increases in technology have also been used to support individuals with cognitive disability. Cognitive dysfunctions, more specifically memory impairments, can significantly impact an individual's quality of life, as well as their educational and vocational outcomes (Wade & Troy, 2001). As a result, the use of cognitive assistive technology (CAT) devices has gained popularity as a long term solution to compensate for cognitive impairments following TBI. CAT devices, sometimes called cognitive orthotics, are designed to be used for individuals with cognitive impairments as a means to support weakened or poor cognitive functions (Bergman, 2002). The goal of CAT is to reinforce an individual's residual abilities, provide alternative means for completing a desired activity, or serve as an extrinsic support (LoPresti, Mihailidis, & Kirsch, 2004).

While compensating for memory deficits is one of the main uses of CAT, this category of assistive technology may also be used in the rehabilitation of, or compensation for, difficulties and limitations in complex attention, executing reasoning, sequential processing, and self-monitoring for specific behaviors. CAT devices may include tape recorders, pagers, watch alarms, personal digital assistants, and mobile telephones (Kim, Burke, Dowd, & George, 1999; Wilson, Emslie, Quirk, & Evans, 2001; Wright, Rogers, Hall, Wilson, Evans, Emslie, & Bartram, 2001; LoPresti et al., 2004). Additionally, CAT may be broken down into categories based upon the cognitive domain they are designed to compensate. Memory and executive functions technologies focus on compensation for memory, planning and problem solving and context-awareness, while technologies for impairments in information processing focus on compensation for context for sensory processing and compensation for social and behavior issues (LoPresti, Mihailidis, & Kirsch, 2004). Wilson, Emslie, Quirk, and Evans (2001) state that these external memory aids are generally the best compensatory strategy for individuals with memory deficits, however, they are also difficult to use because of these difficulties in memory, as individuals often forget to utilize the strategy. Wilson et al. (2001) also state "The employment of external memory aids is in itself a memory task, so the people who need them most typically have the greatest problems in using them" (p.477). Kapur, Glisky, and Wilson (2004) report that memory aids are useful in five ways: electronic diaries to keep track of appointments, alarms to provide auditory cues, with or without visual cues, and specific times, temporary stores for lists, permanent stores for important information such as addresses and telephones, and communication devices that can send and receive information to the user.

Even though difficulties in usage exist, research has still proven memory aids to be an effective strategy to help lessen the impact of memory deficits (Wilson et al., 2001). Gillespie, Best, and O'Neill (2012) conducted a systematic review evaluating the relationship between CAT and general cognitive function. In total, 89 published articles were evaluated using the WHO International Classification of Functioning, Disability and Health to categorize cognitive domains. Gillespie et al (2012) found that CAT can be classified into domains of attention, calculation, emotions, experience of self and time, higher-level cognitive functions such as organization and planning, problem-solving, and time management, and memory functions. Results indicated empirical support for the use of CAT specifically to mitigate memory deficits is limited, however these devices aimed to assist in the registering, storing, and retrieving of information. Technologies for the high-level cognitive functions, specifically time management functions that are a component of prospective memory have been found to be effective in individuals with cognitive impairments (Gillespie et al., 2012; Wilson et al., 2001).

Like any assistive technology device, CAT should be prescribed to meet the complex needs of individuals with TBI. Cole (1999) defined a cognitive prosthetic as a device that uses computer technology, is designed specifically for rehabilitation purposes, directly assists the individual in performing daily activities, and has a high ease of customization to the specific needs of the individual. While the customization of assistive technology is especially important in working with the complex sequelae of TBI, most technology is designed for use in the general population and may pose significant barriers to implementation for individuals with TBI (Kim, Burke, Dowd, Robinson, Boone, & Park, 2000). Advances in smart mobile telephones have increased access for the general population in using features once reserved for a PDA, and recommending technology that is used in the general population has possible benefits because of a decreased stigma in using a rehabilitation device.

A recent study conducted by de Joode, van Boxtel, Verhey, and van Heugten, (2012) indicated that most rehabilitation professionals report being willing to use assistive technology in cognitive rehabilitation for individuals with TBI, however, only 27% are actually using CAT in the rehabilitation setting. Rehabilitation professionals that have experience with CAT reported being more positive about their ability to use these devices in cognitive rehabilitation. Similar results were found for clients and caregivers that they are positive about using assistive technology, but few were actually using it. Training and education opportunities about the benefits of technology are vital to increase clinicians, clients, and caregivers comfort with technology and increase the likelihood of technology being utilized during cognitive rehabilitation (de Joode, van Boxtel, Verhey, & van Heugten, 2012).

Virtual reality is another application of technology that can be applied to help within the rehabilitation of cognitive deficits. Virtual reality is often used in education, physical rehabilitation, and military training settings (Rizzo, Buckwalter, & Neumann, 1997). Recently, virtual reality has also been used as an aid to vocational rehabilitation services when real-life training is not advised due to cost or client safety (Brooks & Rose, 2003). Less immersive virtual environments that can run on a PC are good options for cognitive rehabilitation because they are portable, relatively inexpensive compared to fully immersive technologies, and are less frightening for the clients (Brooks & Rose, 2003). Rizzo, Buckwalter, Neumann (1997) identify several advantages to using virtual reality within cognitive rehabilitation, including control of stimuli delivery, the ability to present ecologically valid training scenarios that are difficult to present using other options, the ability to provide cueing stimuli that aim to guide successful performance within an errorless learning model, the ability to provide immediate feedback to the client, and the ability for a more naturalistic environment for the client to interact.

2.8.3 Efficacy of Cognitive Rehabilitation

The National Institute of Health formed a consensus panel that conducted a meta-analysis on cognitive rehabilitation research. Literature from 1988 to 1998 was searched through MEDLINE and 2563 references were gathered and the panel found compensatory cognitive rehabilitation resulted in significant improvements in health outcomes (National Institute of Health Consensus Statement, 1998). Cicerone and colleagues conducted three meta-analyses on cognitive rehabilitation outcomes after acquired brain injury which resulted in over 1,000 articles. Results from the meta-analyses found that cognitive rehabilitation works best when it is initiated soon after injury and is conducted by a multidisciplinary team of professionals. Cognitive rehabilitation should also be continued as the individual transitions back into the community after rehabilitation discharge. Results from the meta-analyses also found that adaptive compensatory approaches offered within a naturalized context improve functioning in everyday life, and computerized reminder systems and organizational tools effectively manage memory deficits (Cicerone et al., 2000; Cicerone et al., 2005; Cicerone, Langenbahn, Braden, Malec, Kalmar, Fraas, et al., 2011).

Rohling, Faust, Beverly, and Demakis (2009) evaluated the effectiveness of cognitive rehabilitation using Cicerone et al.'s first two meta-analyses and found a small treatment effect size (ES = 0.30) that was directly attributable to cognitive rehabilitation and were moderated by cognitive domain treated, time since injury, typed of brain injury, and age. The authors stated the results revealed sufficient evidence for the effectiveness of cognitive rehabilitation in attention training after TBI. Several additional review articles on the efficacy of cognitive rehabilitation have been published, particularly for individuals with TBI (Carney, Chesnut, Maynard, Mann, Patterson, Helfand, 1999; Uomoto & Williams, 2009).

For individuals with cognitive disabilities, generalization of clinically learned cognitive rehabilitation strategies is limited (Boman, Lindstedt, Hemmingsson, & Bartfai, 2004). Additionally, individuals have difficulty applying strategies learned in the clinic to their home and work environments (Lee, Powell, & Esdaile, 2001; Sohlberg & Raskin, 1996). As a result, to facilitate increased generalization to everyday life, rehabilitation services should be conducted in the home and community environments, as much as possible (Bergquist, Boll, Corrigan, Harley, Malec, Millis, et al., 1994; Uomoto, 1992). Ideally, these natural environments are the most familiar to the client and promote generalization (Mateer, Sohlberg, & Youngman, 1990).

In general, cognitive rehabilitation employs a wide range of strategies that ultimately aim to improve the person's overall functioning. Because of the wide variety of the research related variables that include a range of treatment techniques, the outcome measures, treatment format and length of treatment, obtaining a general conclusion is difficult. As a result, researchers have begun opting to evaluate individual cognitive rehabilitation techniques (Hampstead, Sathian, Phillips, Amaraneni, Delaune, & Stringer, 2012).

2.9 REHABILITATION OF MEMORY DEFICITS

While cognitive rehabilitation targets more general cognitive deficits, memory specific interventions are available. Interventions that are frequently used in the rehabilitation of memory deficits include prospective memory training, repetitive recall drills, and the use of mnemonics and assistive technology. While there are different perspectives on the types of rehabilitation interventions, and some overlap occurs with the different approaches, the rehabilitation interventions can generally be arranged into the following categories.

2.9.1 Direct Retraining

Also known as memory practice drills, direct retaining is one of the oldest approaches for the treatment of memory impairments (Sohlberg & Mateer, 2001; Franzen & Haut, 1991; Schacter & Glisky, 1986). Direct retraining involves giving the person a set of exercises with which to practice memory skills. The theories behind direct retraining include common, repeated exposure and practice will increase memory for that information, and the general rehabilitation idea that there is strength through rehabilitation (Schacter & Glisky, 1986). Another rehabilitation practice for individuals with memory deficits are memory practice drills and are generally conducted through memory exercises in workbooks or through computer programs (Sohlberg & Mateer, 2001). Research has failed to support general improvements in memory functioning through direct retraining strategies. Although empirical support is lacking, many computer games and workbooks are still used in clinical practice (Sohlberg & Mateer, 2001). Similarly, repetitive recall drills generally involve list learning and paragraph recall tasks (Sohlberg, White, Evans, & Mateer, 1992a) and have been adapted into computer programs that are commercially available (Bracy, 1985; Sohlberg & Mateer, 2001). Research has documented that repetitive recall tasks have been unsuccessful in improving memory on untrained tasks or functional memory outside of the laboratory or clinical setting (Prigatano, Fordyce, Zeiner, Roueche, Pepping, & Wood, 1984).

2.9.2 Mnemonic Strategy Training and Organizational Techniques

Another early memory intervention is mnemonic strategy training. Mnemonic strategies include the use of visual imagery, verbal organization strategies such as acronyms and pairs association, and semantic elaboration such as linking targeted words (Ruff, Niemann, Troster, & Mateer, 1990; Sohlberg & Mateer, 2001). The most popular form of mnemonic strategy training is the use of visual imagery which includes teaching a client to create a visual image of the information that needs to be remembered (Wilson, 1986).

One of the most frequently used organizational techniques is to create an acronym from the first letter of each in a series of words to form a single word. An example of this organizational technique to remember the Microsoft Office products for an individual who is studying to become a computer technician is WEAP, representing Word, Excel, Access, and PowerPoint (Haskins et al., 2012).

Research has found mnemonic training appears to work best in artificial laboratory situations and often has limited benefit in real life contexts due to the difficulty in learning these strategies and implementing them spontaneously (Wilson, 1982; Sohlberg & Mateer, 2001). For example, these strategies work well to memorize a list of words, but functional activities that could benefit from mnemonics do not occur with enough frequency for sustained use in everyday activities (Sohlberg, White, Evans, & Mateer, 1992a).

2.9.3 Metacognitive Strategy Training

Metamemory is the understanding of one's own memory, factors that affect it, and strategies to facilitate it. It is an element of metacognition and providing metamemory strategy training is another strategy for the rehabilitation of memory deficits (Sohlberg and Mateer, 2001). The key component of metamemory training includes awareness training. Strategies used for metamemory training includes the awareness regarding individual memory disturbances, and may include educational information regarding memory impairments or allowing a client to experience the effects of their performance with memory activities with their actual performance (Sohlberg and Mateer, 2001). One broader metacognitive strategy training that can be adapted for memory includes the use of estimates and actuals. This strategy revolves around predicting performance which requires clients to predict how they think they will perform on a task and how they actually perform. According to Rebmann and Hannon (1995), clients predicted how they would perform on memory tests and were reinforced for their predictions accuracy. With continued reinforcement, differences between predicted scores and actual scores decreased.

2.9.4 Prospective Memory Training

Another rehabilitation intervention for memory deficits is prospective memory training. Clients, usually with brain injuries, are administered repetitive prospective memory tasks. Clinicians ask clients to carry out a task in a specified number of minutes. Prospective memory training involves systematically extending the length of time that an individual can remember to carry out future assigned tasks. The rehabilitation specialist presents a memory task and documents the client's ability to remember to do the task as a specified time. As the client's prospective memory improves, the length of time between the task presentation and execution is extended, as well as the complexity of the task (Sohlberg, White, Evans, & Mateer, 1992b).

Prospective memory training may also be recognized as the spaced retrieval technique. In the spaced retrieval technique, the client is asked to remember certain pieces of information for progressively longer intervals and can be lengthened based upon the client's performance on previous trials, as well as the complexity of information the client needs to remember (Haskins et al., 2012). Brush and Camp (1998) suggest that client's be screened for their ability to learn new information through errorless learning. Errorless learning is the client's ability to recall a statement that was just presented to the client without a delay (Haskins et al., 2012). Errorless learning is a method of learning that involves the elimination of errors during the learning process. This occurs by breaking down the task into small steps, providing the client with models before they perform the same task, encouraging the client to avoid guessing, immediately correcting errors, and then gradually fading the prompts (Clare & Jones, 2008; Sohlberg, Ehlhardt, & Kennedy, 2005). An example of this in a rehabilitation setting is stating to the client "My name is Dr. Smith. 'What is my name?'" (Haskins et al., 2012, pg. 49). This can be complicated by adding a command with a conditional clause attached to the command. Another example would include "When you pick up the phone, say 'Hello, this is Evelyn. What should you say when you pick up the phone?'" (Haskins et al., 2012, pg. 49). Spaced retrieval is identical to errorless learning however, spaced retrieval extends the amount of time the client must remember the presented information (Haskins et al., 2012).

2.9.5 Association Techniques and Priming

Similar to organizational strategies, association techniques are a memory strategy that requires the client to link or associate two or more items that need to be learned together (Haskins et al., 2012). Association techniques have been employed to learn and recall people's names. This is accomplished by linking the person's name, verbal information, with the person's picture or an image of the face. Wilson (2009) taught clients to link prominent facial features to the client's name.

Another association technique is the use of the visual peg words system (Patten, 1972; Wilson, 2009). Visual pegs are a standard set of words listed in a fixed sequence, and rhyme with the associated number. The typical first four pegs include zero-hero, one-bun, two-shoe, and three-tree, and generally continue up to the number 12. When a client is trying to learn new information, each item is paired with one peg word and that peg word is then linked to a visual image of that peg word and associated with the item to be remembered.

The method of loci technique is similar to the peg system, except that the visual images of items to be learned are linked to a different location within a well-known place to the client (West, 1995). As the client mentally scans through the location, the learned items that have been linked with a specific place in the room will be remembered (Haskins et al., 2012).

Priming is another method of implicit learning that provides increased chance of retrieval when a person is previously exposed to information without explicit learning. Priming is a phenomenon that states cues can prompt accurate recall without an individual's even being aware of or recalling that the information was previously presented. Stem completion activities are the classic priming examples.

2.9.6 Vanishing Cues

Even in individuals with severe memory impairments, intact repetition priming is exhibited (Glisky, Schacter, & Tulving, 1986). As a result, researchers have developed a memory intervention technique called the method of vanishing cues. This method of vanishing cues is a faded cueing technique that can be used to teach complex knowledge or behaviors that might be used in everyday life. The client is first provided enough information to make a correct response, and then parts of the information are gradually withdraws across learning trials, so the person receives fewer and fewer cues.

2.9.7 External Memory Compensations

In the rehabilitation of memory deficits, several types of paper based and cognitive assistive technology external devices have been used, including memory notebooks or memory logs, personal digital assistants (PDA), smart cell phones, voice recorders and voice organizers, and paging systems. Gentry, Wallace, Kvarfordt, & Lynch (2008) evaluated 23 individuals with TBI pre and post intervention to determine the efficacy of PDAs as a cognitive aid in individuals with severe TBI. Each client was given a PDA plus they received 3-6, 90 minute training visits from an OT in home for no longer than a 30 day period. The training included one-on-one verbal training, demonstration, and instructional literature to meet the individual learning styles and needs. Results indicated increased performance, satisfaction, cognitive independence, mobility, and occupation as measured by the Canadian Occupational Performance Measure and the Craig Handicap Assessment and Reporting Technique. Gillette and DePompei (2008) evaluated two types of PDA's, paper planners, and times and tasks list for students with TBI and adults with intellectual disabilities. Students were on time significantly more frequently using a PDA compared to paper planners and lists.

Table 3 displays a breakdown cognitive strategies, low-tech devices, and high-tech devices to aid in memory rehabilitation.

Table 3. Approaches to Memory Rehabilitation

Cognitive Strategies	**Low-tech Devices**	**High-tech Devices**
Divide larger tasks into smaller tasks and steps	Data Planners	PDA's/cell phones
To-Do Lists/Check lists	Tape Recorders	Specialized PDA's
Reduce/Minimize distractions	Clocks	Paging systems
Detailed written Instructions	Calendars	
Rest Periods	Timers	
Provide additional time to learn new responsibilities	Digital Watches	
Record meetings		
Written summaries		

2.9.8 General or Multiple Memory Domains

Due to the complexity of the memory processes, rehabilitation of memory deficits often uses a combination of interventions and strategies.

The Ecologically Oriented Neurorehabilitation of Memory (EON-MEM) is a 21-week, systematic, structured, and detailed treatment manual approach to cognitive rehabilitation designed to train clients to compensate for memory impairments. Focus is placed on everyday memory problems and practice exercises in naturalistic environments, which provide ecological validity to the program. The EON-MEM teaches clients using a four-step method for remembering information using compensatory strategies that incorporate mnemonics and written aids. This four-step method uses the tools Write, Organize, Picture, and Rehearse (WOPR). Additionally, the EON-MEM teaches clients to use the peg system for remembering numbers.

The peg system is a series of words that rhyme with numbers 0 through 12 (e.g., 0-hero, 1-bun, 2-shoe, etc.). The peg system is easy to learn and allows clients to visualize (Picture), further emphasizing the WOPR system. Finally, each week, clients are introduced to a new module and then given 7 homework assignments that must be completed one each day (Stringer, 2007). The EON-MEM was developed to be consistent with best practices in cognitive rehabilitation identified by Chestnut, Carney, Maynard, Mann, Patterson, & Helfand (1999) and by Cicerone, Dahlberg, Kalmar, Langenbahn, Malec, Bergquist, et al. (2000). The EON-MEM also advocates for the use of alarms and electronic devices to aid in memory, thereby following evidence-based reviews to incorporate additional strategies and techniques in cognitive rehabilitation. The Therapist Guide also details that some individuals may not need every module in the protocol, while some many need additional time spent on a particular area, allowing for customization of the cognitive rehabilitation protocol. Regardless of the types of techniques, strategy training is most effective for individuals with mild to moderate memory impairments (Kaschel, Della Salla, Cantagallo, Fahlbock, Laaksonen, & Kazen, 2002). Additionally, for individuals with moderate to severe memory impairments, incorporating external compensations may be necessary to assist with strategy utilization (Haskins et al., 2012).

2.10 EVIDENCED BASED COGNITIVE REHABILITATION FOR MEMORY DEFICITS

Several reviews on the efficacy of cognitive rehabilitation for memory deficits have been conducted. Jean, Bergeron, Thivierge, & Simard (2010) conducted a systematic literature review to determine the efficacy of cognitive intervention programs for individuals with amnestic type mild cognitive impairment, possibly at risk to progress toward dementia. Fifteen cognitive intervention programs were evaluated. Results from the review showed statistically significant improvements in memory in 44% of objective measures of memory and 49% of subjective measures of memory.

Stott and Spector (2010) also conducted a systematic review focusing on memory interventions for individuals with mild cognitive impairment. Stott and Spector (2010) cite several methodological limitations with the Jean at al. (2010) systematic review. First, the authors included programs not designed specifically for memory, but aimed at quality of life. Additionally, Jean et al. included case studies in their review, which hold little weight in scientific rigor. Stott and Spector (2010) evaluated ten studies focusing on memory interventions for individuals with mild cognitive impairment. Results from the systematic review cautiously suggest that people with mild cognitive impairment can learn specific information, although there was little evidence to suggest that memory training can generalize. Additionally, there was some limited evidence of ability to learn to compensate for memory difficulties and contradictory findings regarding improvement in everyday life. Stott and Spector state the methodological quality of studies included in their review is poor and limits the ability to draw conclusions about memory interventions for people with mild cognitive impairment. Their results also state there are some indications that memory impairment in mild cognitive impairment might best be targeted by interventions developing compensatory strategies and targeting the learning of specific information relevant to the individual.

Several studies have been conducted on the efficacy of prospective memory rehabilitation. Sohlberg, Mateer, and Geyer (1985) developed a prospective memory training program called Prospective Memory Process Training (PROMPT). PROMPT asks clients to remember to carry out a specified task in a predetermined number or minutes. As the client demonstrates repeated success at a particular time interval, the number of minutes until the specified task is increased. A non-experimental, descriptive case study using PROMPT resulted in a significant and steady increase in one participant's prospective memory ability over time (Sohlberg et al., 1992a).

Fleming, Shum, Strong, and Lightbody (2005) conducted an 8-week prospective memory rehabilitation program that included self-awareness training, selection of an appropriate organizational device, analysis of cueing, organizational strategies with three participants with TBI. The prospective memory protocol used in this study was based loosely off of Sohlberg's model (Sohlberg, Mateer, & Geyer 1985). The program also focused on generalization strategies to aid in the transfer or strategies to their everyday lives. Results showed all participants improved on formal measures of prospective memory testing. Between the three participants, self-report memory difficulties varied, with some participants self-reported more prospective memory problems, however Fleming et al. attribute these differences to a possible increase in self-awareness (2005).

Shum, Fleming, Gill, Gullo, and Strong (2011) conducted a randomized controlled trial to examine the efficacy of compensatory prospective memory training, after participants received self-awareness training for adults with traumatic brain injury. Shum et al. randomized participants into four groups: self-awareness training plus compensatory prospective memory training, self-awareness training plus individual therapy not related to memory or self-awareness (active control), active control plus compensatory prospective memory training, or active control only. Forty-five individuals with TBI received eight sessions of the individualized program and participated in memory testing before and after the intervention. Individuals who received prospective training achieved the largest change in memory functioning, regardless of self-awareness training. Results indicate that individuals with TBI can see improvements in prospective memory functioning within a short time frame and through a low intensity intervention.

Thickpenny-Davis and Barker-Collo (2007) also evaluated a structured eight session intervention, but delivered to individuals in a group format instead of individually. Twelve individuals with TBI and cerebral vascular accident were randomly assigned to the intervention group or a wait-list control group. Individuals in the intervention group received eight 60-minute psychoeducational sessions held over a four week period. The modules included an introduction to memory, the four parts of memory, attention and encoding, strategies to improve attention, strategies to increase encoding, and information about memory storage and retrieval strategies. Participants in the intervention group significantly improved their memory function, as measured by neuropsychological testing and self-report questionnaires, as well as basic knowledge of memory and memory strategies. This improvement was maintained 1-month after completion of the intervention.

Hampstead, Sathian, Moore, Nalisnick, & Stringer (2008) conducted a study on explicit memory training using face-name association. Eight individuals with amnestic multiple domain mild cognitive impairment, participated in three training sessions over two-weeks. Participants were shown 90 faces and were instructed to remember the face-name associations. The faces were divided into two groups of 45. Participants were then assigned to one of the groups of 45 and participated in an additional three training sessions utilizing the Biographical Information Module from the EON-MEM program. All participants received the EON-MEM training. Participants performed significantly better on the trained list than the untrained list. Results showed both the trained and the untrained list of 45 faces relative to baseline. These results may indicate generalization of the training.

As a follow-up to their explicit memory training study, Hampstead, Sathian, Phillips, Amaraneni, Delaune, & Stringer (2012) conducted a study to evaluate mnemonic strategy training to improve memory for object location associations for healthy older adults and adults with amnestic mild cognitive impairment. Participants either received mnemonic strategy training or a matched-exposure group. All participants participated in five sessions, completed over a two week period. Results indicated that mnemonic strategy training was more beneficial than exposure alone, immediately after training and lasted for at least a month after completion of the intervention.

Stringer (2011) conducted a pre to post treatment comparison of memory rehabilitation to evaluate the robustness of the EON-MEM. Participants included individuals with stroke, TBI, and other neurological impairment and were classified into mild/moderate memory impairment and severe memory impairment. Results showed statistically significant improvement in memory performance for declarative and prospective memory tasks, regardless of disability etiology, as well as the severity of the memory impairment.

2.11 ACCESS TO COGNITIVE REHABILITATION SERVICES

Rural and remote areas often have limited access to resources and to skilled professions trained to deliver specialized medical and rehabilitation services (Callas, Ricci, & Caputo, 2000). Further, access to rehabilitation service is more difficult for individuals with disabilities who live in rural locations, compared to metropolitan areas (Demiris, Shigaki, & Schopp, 2005). Barriers to rehabilitation services for rural areas include distance to facilities, limited or lack of transportation, rural poverty, and lack of rural service providers (Schopp, Johnstone, & Merrel, 2000). As a result, individuals with disabilities may not receive the appropriate level of care due to the lack of access to specialty services and to new technologies (Johnstone, Nossaman, Schopp, Holmquist, & Rupright, 2002). Research has also found the greater the distance individuals must travel to obtain services, the less likely people are likely to receive that service (Johnson, Weinert, & Richardson, 1998). Although there is an equal geographic distribution of individuals with ADHD, there are limited evidenced based treatment resources available for individuals in rural communities and for individuals who are of an ethnic minority (Hoagwood, Kelleher, Feil, & Comer, 2000). With the increases in diagnoses of ADHD and ASD, and the number of TBIs sustained yearly, combined with the limited resources available for these populations, rehabilitation service providers are struggling to keep up with the demand.

2.12 SUMMARY

Memory is a complex set of processes that impact a person's ability to function independently. Deficits in memory, especially prospective memory, negatively impact an individual's ability to be successful personally, academically, and vocationally. Individuals with cognitive disability experience a wide range of cognitive, social, academic, and employment difficulties, regardless of disability etiology. While memory impairments have been widely researched in individuals with TBI, memory deficits are evident in many cognitive disabilities. As a result, strategies to remediate memory deficits need to be broadened past strictly looking at the outcome of TBI interventions.

Although memory deficits may have a negative impact on everyday life, cognitive rehabilitation strategies may lessen the impact of memory and improve everyday function. Cognitive rehabilitation aims to lessen the impact of these difficulties by remediating some of the cognitive, social, and employment barriers individuals' face, either through identification of supports to bolster weaker skills or through the establishment of new strategies that support an individual's strengths. Generally, cognitive rehabilitation focuses globally on functional challenges, as opposed to cognitive domain specific interventions. Although it cannot be addressed independently, many strategies to mitigate memory deficits do exist. While cognitive rehabilitation has been proven effective if implemented early, delivered through multidisciplinary teams and in the naturalistic environment, access to services may be limited for individuals who live in rural areas and may limit services to individuals who need them.

3.0 REVIEW OF REMOTE INTERVENTIONS FOR ADULTS WITH COGNITIVE DISABILITY

3.1 METHODS

Research studies were identified through electronic database searches. The databases Ovid Medline (1946-2012) the premier medical database, which uses controlled vocabulary Medical Subject Headings, PsychInfo (1967-2012), Cumulative Index to Nursing & Allied Health Literature, Academic Search Premier, and Expanded Academic ASAP, were searched. Keywords and phrases entered included: telerehabilitation, telepsychiatry, telepsychology, telehealth, telemedicine, and cognitive disability, attention deficit/hyperactivity disorder, traumatic brain injury, Asperger's Disorder, autism spectrum disorder, and learning disorder.

The articles included for review included keywords or phrases previously identified in the title or abstract. Additional inclusion criteria were: a) peer reviewed and published in referenced scientific journals or from conference proceedings, b) written in the English language c) published since 2000. The reference lists of relevant publications were also reviewed to identify further studies that met the inclusion criteria. Articles were excluded if the study was unrelated to cognitive disability (e.g. psychiatric or intellectual disabilities), cognitive rehabilitation or telerehabilitation applications.

3.2 TELEREHABILITATION

Telemedicine can be defined as the use of telecommunications for the transmission of information relevant to the diagnosis and treatment of medical conditions. Additionally, telemedicine can be defined as the provision of health services or the consultation for healthcare personnel at distant sites (Maheu & Allen, n.d.). Telemedicine has evolved to telehealth to represent a broader scope that also consists of health promotion and disease prevention (Koch, 2006); however there is no clear distinction between telemedicine and telehealth (Maheu & Allen). As a result, the definition of telehealth was expanded to the use of electronic telecommunications for the transmission of information and data focused on health promotion, disease prevention, diagnosis, consultation, education, and/or therapy, and the public's overall health (Maheu & Allen).

Telepsychiatry has been described as the delivery of healthcare and the exchange of healthcare information for the purposes of providing psychiatric services across distances (Wootoon, Yellowlees, & McLaren, 2003). Further, telepsychology has been described as the provision of psychological services through electronic tools (Rees & Haythornthwaite, 2004). While telepsychology is a recognized field within telehealth, it has not reached the developmental level of telepsychiatry (Rees & Haythornthwaite, 2004).

Keeping in mind the foundation of telemedicine, telerehabilitation (TR) is simply defined as the application of telecommunication technology for facilitating rehabilitation services (Russell, 2007). TR services may include consultations, homecare, monitoring, therapy, and direct patient care delivered to locations including, work settings, home, community, nursing homes and other health care facilities (Seelman & Hartman, 2009). Additionally, telemonitoring, teleconsultation, teleeducation, telesupervision, and teletherapy with or without physical intervention, are all TR applications (Forducey, Ruwe, Dawson, Scheideman-Miller, McDonald, & Hantla, 2003). Additionally, TR has the capacity to provide health care services in rural areas, enlarge rehabilitation opportunities for clients by using computer-aided systems, improve quality of life, reduce medical costs, and reduce travel time (Rogante, Grigioni, Cordella, and Giacomozzi, 2010; Egner, Phillips, Vora, & Wiggers, 2003; Torsney, 2003; Zheng, Black, & Harris, 2005; Park, Peng, & Zhang, 2008).

TR offers a unique benefit by increasing rehabilitation service providers' ability to intervene within the context of the client's natural environment, allowing emphasis on an individual's everyday functioning. Naturalistic treatment increases functional outcomes, addresses problems with generalizability, and enhances patient satisfaction and self-direction. In general, it is hypothesized that providing rehabilitation services in the environment where the client must eventually succeed may produce greater clinical outcomes (Pace, Schlund, Hazard-Haupt, Christensen, Lashno, McIver, et al., 1999).

Over the past few years, several systematic review articles of TR outcomes have been published. Rogante, Grigioni, Cordella, and Giacomozzi (2010) conducted a review of the first ten years of TR ranging from 1998 to 2008. Overall, Rogante et al. found a total of 146 articles. Within their review, 31 articles focusing on cognitive disabilities were found and included both cognitive and physical rehabilitation interventions. Kairy, Lehoux, Vincent, & Visintin (2009) also conducted a systematic review and found 28 articles through February 2007. Of these 28 articles, only six articles dealt with individuals with cognitive or neurological disabilities. Results from both systematic reviews found a lack of standardization in terminologies used, as well as limited comprehensive studies that provide variable evidence for TR. Overall, Kairy et al. (2009) found that clients who received TR services were generally satisfied with the services received.

As previously mentioned, generalization of clinically learned cognitive rehabilitation strategies is limited, especially for those with TBI, (Boman, Lindstedt, Hemmingsson, & Bartfai, 2004). Individuals with cognitive disabilities often have difficulty applying strategies learned in the clinic to their home and work environments to their everyday life situations (Lee, Powell, & Esdaile, 2001; Sohlberg & Raskin, 1996). As a result, to facilitate increased generalization to everyday life, rehabilitation services should be conducted in the home and community environments, as much as possible since these natural environments are the most familiar to the client and promote generalization (Bergquist, Boll, Corrigan, Harley, Malec, Millis, et al., 1994; Uomoto, 1992; Mateer, Sohlberg, & Youngman, 1990). Further, naturalistic treatment has the potential to increase functional outcomes, addresses problems with generalizability, and enhances patient satisfaction and self-direction (McCue, Fairman, & Pramuka, 2010)

3.3 REMOTE INTERVENTIONS FOR PERSONS WITH COGNITIVE DISABILITY

3.3.1 Attention Deficit Hyperactivity Disorder

Attention deficit/hyperactivity disorder (ADHD) is one of the most common and chronic disorders of childhood (American Psychiatric Association (APA), 2000). Due to the chronicity of ADHD, there is a major need for health care resources, making ADHD a public health issue (DeBar, Lynch, & Boles, 2004; Leibson, Katusic, Barbaresi, Ransom, & O'Brien, 2001). Palmer, Meyers, Vander Stoep, McCarty, Geyer, & DeSalvo (2010) conducted a review on the use of telepsychiatry with children and adolescents and found ADHD is one of the most common disorders treated through telepsychiatry in Washington and Alaska. They also found there is limited outcomes research for the use of TR and ADHD. Additionally, intervention studies using TR technologies are currently being initiated in various parts of the country (Palmer et al. 2010).

3.3.2 Brain Injuries

While limited research has been conducted on teleinterventions in individuals with ADHD, there has been an increase in the research conducted with individuals who have a traumatic brain injury (TBI). Ricker, Rosenthal, Garay, Deluca, Germain, Abraham-Fuchs, et al. (2002) conducted a TR needs assessment for individuals with acquired brain injury (ABI). Results from this study revealed individuals with ABI have an interest in accessing TR services, especially in services that could address problems in memory, attention, problem-solving, and activities of daily living.

Bergquist, Gehl, Lepore, Holzworth, and Beaulieu (2008) conducted a study to assess the feasibility of an Internet-based cognitive rehabilitation program for individuals with ABI and memory impairment. Ten individuals with ABI and documented memory impairments completed one training session on how to use an instant messaging (IM) system. Participants used the IM system from their home computer to participate in 'therapy' sessions focusing on the development calendar skills with a rehabilitation therapist. Calendar sessions aimed to address difficulties with memory in day-today life and develop strategies to improve memory functioning in identified aspects of day-to-day life. Participants averaged 32 total therapy sessions, with a range between 12–62 sessions. Another variable of interest to determine feasibility was the number of missed sessions. Eight of the 10 participants did not miss any of their first 10 sessions. One participant missed one session, while the other participant missed three sessions, for a total of four missed sessions out of a total 100 resulting in a "no show" rate of 4.0% (Bergquist, Gehl, Lepore, Holzworth, & Beaulieu, 2008).

Bergquist, Gehl, Mandrekar, Lepore, Hanna, Osten et al. (2009) continued using the IM system and calendar acquisition intervention for individuals with TBI to examine whether cognitive rehabilitation delivered over the Internet was associated with improvements in functioning. Using a cross-over study design, 14 individuals with TBI completed 60 online sessions, 30 sessions of an active calendar acquisition intervention and 30 sessions of a control diary condition. Results showed no significant differences in memory functioning between the intervention and control conditions. Analyses between baseline and final assessments after all 60 online sessions found statistically significant improvements in use of compensatory strategies, as well as family reports of improved memory and mood. Results also showed individuals who used fewer compensatory strategies at baseline were significantly less likely to complete the study. The results suggest that compensatory cognitive rehabilitation may be effectively delivered via the Internet, particularly among individuals who are already utilizing some basic compensatory strategies.

Diamond, Shreve, Bonilla, Johnston, Morodan, and Branneck (2003) built a virtual rehabilitation center that provides rehabilitation, education and support services to individuals with TBI and aimed to determine relationships between the nature and severity of the participants' cognitive impairments and their ability to use the virtual rehabilitation center. The virtual rehabilitation center was delivered using a desktop PC with a 17-inch screen, web cam, microphone, and headphones. All individuals learned how to use the virtual rehabilitation center, but those with a greater severity took longer to become acclimated to the system.

Man, Soong, Tam, & Hui-Chan (2006) conducted a pre-post quasi experimental research study designed to determine the effectiveness of three interventions for problem solving delivered by three different modes, online training (through computer videoconferencing with interactive software), computer-assisted training (through interactive patient-directed software), and therapist administered training (face-to-face (FTF) therapist guided training activities). The research also included a no-treatment control group. Each intervention group received 20 sessions in problem solving skills training. Individuals who received problem solving skills training significantly improved in basic and functional problem-solving skills; however, there was no significant difference between the intervention groups. Individuals in the FTF group also improved in their level self-efficacy, but not in the online or the computer-assisted groups. Results suggest that TR could effectively deliver cognitive rehabilitation to individuals with TBI as compared to FTF services.

Bell, Temkin, Esselman, Doctor, Bombardier, Fraser et al. (2005) examined the difference in behavioral outcomes in individuals with TBI between a telephone intervention compared to standard follow-up at one year post injury. Individuals in the intervention group received telephone calls 2 weeks after discharge from inpatient rehabilitation and again at 4 weeks and 2, 3, 5, 7, and 9 months after discharge. Each phone call consisted of 3 components. A research case manager would follow up on concerns the individual raised during the previous telephone interaction. The case manager would then have the individual or family members identify the current problems including behavioral problems, physical or cognitive problems, and financial or legal problems. Finally, the case manager would facilitate the prioritization of the individual's problems and aid in problem solving ways to address each concern. Telephone intervention offered brief motivational interviewing, counseling and education to individuals with TBI. Results from this study show individuals who received the telephone intervention progressed significantly better overall than individuals in the treatment as usual group, as well as in measures of functional status and quality of life. No significant differences were found in measures of vocational status and community integration. Results suggest telephone counseling and education resulted in improved overall outcome, particularly for functional status and quality of well-being, when compared with usual outpatient care.

Bombardier, Bell, Temkin, Fann, Hoffman, & Dikmen (2009) conducted a single-blinded, randomized controlled trial examining the difference between a telephone intervention and treatment as usual for individuals with TBI. The goal of the study was to determine whether an intervention designed to improve functioning after TBI also reduces depressive symptoms. The telephone intervention utilized the same methodology as Bell et al. (2005). Individuals in the TR intervention group reported statistically significant lower depressive symptoms and reported greater improvement in their symptoms as compared to the treatment as usual control group at one year post injury.

Salazar, Warden, Schwab, Spector, Braverman, Walter et al (2000) conducted a study to determine the efficacy of an inpatient cognitive rehabilitation program for individuals with moderate-to-severe TBI recruited from a U.S. military medical referral center. The authors aimed to evaluate return to gainful employment and fitness for military duty at 1-year follow up. Participants were randomized to an intensive, standardized 8-week, in-hospital cognitive rehabilitation program or to a limited in-home rehabilitation program with weekly telephone support from a psychiatric nurse. No significant differences were found between the two interventions in measures of return to employment or in cognitive, behavioral, or quality of life measures. Results suggest both interventions can provide benefits to individuals with TBI.

Bourgeois, Lenius, Turkstra, and Camp (2007) conducted a randomized controlled clinical trial to evaluate the effects of an errorless training approach, spaced retrieval training delivered over the telephone, on the reported everyday memory problems of adults with chronic TBI. Participants were randomized to spaced retrieval training or didactic strategy instruction, each delivered by telephone, and each participant identified three memory-related goals. Individuals in the spaced retrieval group reported significantly more treatment goal mastery and strategy use compared to individuals in the didactic strategy instruction group, immediately and at 1-month post training. Both groups a decrease in the frequency of self-reported memory problems and some generalization in strategy use to other behaviors, however, there was no significant difference between groups. Additionally, neither intervention group reported increases in their perceived quality of life. These results suggest telephone based interventions to improve memory deficits may be effective in individuals with TBI.

Georgeadis, Brennan, Barker, and Baron (2004) conducted FTF and videoconference-based TR comparison study with individuals with TBI and cerebrovascular accident. Participants were asked to retell stories in both the FTF and the TR settings. While there was a high acceptance and interest in the TR setting, no significant difference was found in story retelling performance between the two settings.

Schoenberg, Ruwe, Dawson, McDonald, Houston, and Forducey (2008) compared outcomes between individuals with moderate-to-severe TBI, at least one year post injury, using computer-based cognitive rehabilitation teletherapy program and FTF outpatient speech-language therapy. Outcomes of interest were independent living, independent driving, return to work or to school, and cost of therapy. Individuals in the TR group received an average of 24.4 weeks of therapy, while the participants in the FTF group received 9.8 weeks of therapy, on average. No significant differences were found on any measure between the two interventions, suggesting the cognitive TR program provided similar functional outcomes as FTF speech–language therapy at a similar total cost.

Tam, Man, Hui-Chan, Lau, Yip, and Cheung (2003) presented three case studies with the aim of evaluating the efficacy of an on-line cognitive training program for participant with TBI using a single case ABA reversal experimental design. The experimental design consisted of a no-intervention baseline phase, an intervention phase, and a no-intervention withdrawal phase, each participant receive 18 sessions. Overall, the three persons with brain injury showed improvements in the cognitive performance during the treatment phase and the telecognitive rehabilitation approach was well received by subjects.

3.3.3 Autism Spectrum Disorders

While the literature on TR interventions for individuals with TBI is well documented, the research with individuals who have a diagnosis of an autism spectrum disorder is still limited. Boisvert, Lang, Andrianopoulos, and Boscardin (2010) conducted a systematic review to identify the remote assessment and treatment of individuals with ASD and identified eight studies meeting inclusion criteria. In general, the studies identified in the review were limited by small sample sizes lower levels research designs. Barretto, Wacker, Harding, Lee, and Berg (2006) completed a functional analysis of a five year old male student in a rural classroom. The assessment was conducted by consulting clinician's at a university hospital who supported the local, rural team. The results indicated the functional analysis was able to be conducted remotely and obtained different results from an interview completed without the support of TR. Vismara, Young Stahmer, Griffith, and Rogers (2009) taught community-based early intervention specialists, along with parents, for 29 children, to implement a comprehensive early intervention program within the child's home. Vismara et al. (2009) assigned 10 therapists to an in person instruction group or a telepractice instruction group. No significant differences in the results of changes in the children's social-communicative behaviors, therapist implementation and satisfaction were found between the FTF and the telepractice group, indicating that the distance education was as effective as in person instruction. The remaining studies included the provision of psychiatric evaluations for Native American children residing in rural areas (Savin, Garry, Zuccaro, & Novins, 2005) and consultation services (Gibson, Pennington, Stenhoff, & Hopper, 2010; Machalicek, O'Reilly, Chan, Lang, Rispoli, Davis et al., 2009; Machalicek, O'Reilly, Chan, Rispoli, Lang, Davis et al., 2009; Machalicek, O'Reilly, Rispoli, Davis, Lang, Hetlinger-Franco et al., 2010; Rule, Salzberg, Higbee, Menlove, & Smith, 2006).

More recently, Schutte (2012) conducted a study to evaluate the reliability of conducting autism assessments remotely using the Autism Diagnostic Observation Schedule (ADOS), compared to in person evaluations. Results indicate that remote ADOS assessments produced reliable outcomes and telerehabilitation is a viable option for conducting autism evaluations.

3.3.4 Specific Learning Disorders

While the data supporting the use of TR technologies for individuals with traumatic brain injuries, ADHD, and those on the autism spectrum, literature that solely focused on individuals with specific learning disorders was limited. Waite, Theodoros, Russell, and Cahill (2010) evaluated the reliability and validity of a TR system to assess children's literacy. Twenty children who were identified as having delays, or potentially having delays, in reading or spelling were assessed simultaneously in person and remotely. Although there were some issues with the audio, the overall remote evaluation was found to be reliable and valid to assess children's literacy. Several articles focused on individuals with other developmental and intellectual disabilities and categorized individuals with SLD into these groups (Miller, Elliott, Long, Mazenac, & Moder, 2006; Harper, 2006; Szeftel, Mandelbaum, Sulman-Smith, Naqvi, Lawrence, Szeftel et al., 2011).

3.4 REMOTE COGNITIVE REHABILITATION

Of the remote interventions conducted with adults with cognitive disabilities, few studies provided cognitive rehabilitation remotely. Results from Bergquist, Gehl, Mandrekar, Lepore, Hanna, Osten, et al. (2009) indicated that compensatory cognitive rehabilitation may be effectively delivered via the Internet. As a follow-up to the clinical study, Bergquist, Thompson, Gehl, and Munoz Pineda (2010) evaluated participant satisfaction with receiving cognitive rehabilitation through instant messaging or email and a control group. Both the diary control group and the remote intervention group indicated high levels of satisfaction with the treatment received. Bourgeois, Lenius, Turkstra, & Camp, (2007) conducted spaced retrieval training over the telephone to impact memory problems for adults with TBI, compared to a didactic strategy instruction. Results indicated that individuals in the teletherapy group reported more treatment goals and strategies than individuals in the didactic group. However, both groups improved in self-reported memory problems. Salazar et al. (2010) also provided telephonic interventions to participants in their home and found similar improvements to an in-hospital cognitive rehabilitation group.

The results from these studies show that telehealth technologies such as telephone and two-way messaging can aid in delivering parts of cognitive rehabilitation to clients remotely. However, the studies evaluated did not evaluate any two-way audio and video interactive communications. As a result, there is insufficient evidence to establish whether TR technologies are effective for delivering cognitive rehabilitation remotely (Committee on Cognitive Rehabilitation Therapy for Traumatic Brain Injury, 2011c).

A recent study evaluating the efficacy of a military on-line problem solving intervention was conducted using a matched pre/post design (Riegler, 2012). The participants were provided with a laptop computer, a wireless internet connection, and a videoconferencing phone to complete the intervention. Participants completed six self-guided modules regarding attention, memory, and problem solving, in addition to weekly meetings with a therapist via videoconferencing phone. Six veterans completed the TR intervention and six individuals completed the standard, FTF intervention. Results from a 2x2 ANOVA indicated that both the TR and the FTF groups experienced improvements in memory functioning after treatment, with no significant difference between the two treatment modalities. These results provided preliminary evidence that conducting cognitive rehabilitation remotely is feasible and a basic level of efficacy was determined, however this study was limited by a small sample size (n=12) (Riegler, 2012).

3.5 SUMMARY

TR is the use of telecommunication technologies to facilitate rehabilitation services. While TR has the ability to increase available services, and access to these services for individuals with cognitive disabilities, the use of TR to deliver cognitive rehabilitation is still limited. The available empirical evidence suggests that TR is a feasible method to deliver cognitive rehabilitation, and clients may benefit from remote cognitive rehabilitation, however additional research still needs to be conducted.

While the limited research that is available suggests that cognitive rehabilitation services can be delivered remotely to individuals with cognitive disabilities. As a result, the purpose of this project was to develop a system for the delivery of remote cognitive rehabilitation. Upon completion of development of a new system, deployment into a clinical study to evaluate the equivalency of FTF and TR cognitive rehabilitation interventions, as well as an overall efficacy of the program, were be determined. Clinical usability is also a vital component of the development of any TR system and was also evaluated.

4.0 DEVELOPMENT AND FIDELITY OF A REMOTE COGNITIVE REHABILITATION PROGRAM

4.1 INTRODUCTION

Research has found cognitive rehabilitation is effective, but works best when initiated soon after injury and is conducted by a multidisciplinary team of professionals. Cognitive rehabilitation should also be continued as the individual transitions back into the community after rehabilitation discharge. The cognitive rehabilitation meta-analyses also found that adaptive compensatory approaches offered within a naturalized context improve functioning in everyday life, and computerized reminder systems and organizational tools effectively manage memory deficits (Cicerone, Dahlberg, Kalmar, Langenbahn, Malec, Berquist et al., 2000; Cicerone, Dahlberg, Malec, Langenbahn, Felicetti, Kneipp et al., 2005; Cicerone, Langenbahn, Braden, Malec, Kalmar, Fraas et al., 2011).

While cognitive rehabilitation has the ability to increase functional independence for persons with cognitive disabilities, many individuals do not have access to these specialized rehabilitation services. As a result, telemedicine and telehealth have grown as a way to reach individuals who otherwise may not have access to services. Telerehabilitation (TR) offers a unique benefit by increasing rehabilitation service providers' ability to intervene within the context of the client's natural environment, allowing emphasis on an individual's everyday functioning. Naturalistic treatment increases functional outcomes, addresses problems with generalizability, and enhances patient satisfaction and self-direction (McCue, Fairman, & Pramuka, 2010). Although research has found that individuals benefit from cognitive rehabilitation, and that TR can successfully provide clinical services to underserved populations or within a home context, currently, the research on remote cognitive rehabilitation is limited. The remote cognitive rehabilitation projects defined in the literature are limited in scope to either videoconferencing, telephonic therapy, or computer assisted cognitive rehabilitation. The remote cognitive rehabilitation studies that exist, however, show that TR is as effective as face-to-face (FTF) interventions (Bergquist, Gehl, Mandrekar, Lepore, Hanna, Osten et al., 2009; Bergquist, Thompson, Gehl, & Munoz Pineda, 2010; Bourgeois, Lenius, Turkstra, & Cam, 2007; Salazar, Warden, Schwab, Spector, Braverman, Walter et al., 2000; Man, Soong, Tam, & Hui-Chan, 2006; Schoenberg, Ruwe, Dawson, McDonald, Houston, & Forducey, 2008; Tam, Man, Hui-Chan, Lau, Yip, & Cheung, 2003).

In addition to the different cognitive rehabilitation interventions being conducted remotely, the technologies used are also quite varied. Bergquist et al. (2009 and 2010) conducted their remote interventions using instant messaging programs. Other systems include the creation of virtual reality rehabilitation centers to provide rehabilitation, education, and support services to persons with traumatic brain injury (TBI) (Diamond, Shreve, Bonilla, Johnston, Morodan, & Branneck 2003), telephonic spaced retrieval training for memory problems (Bourgeois et al., 2007), and online cognitive training programs (Tam et al., 2003). Along with interventions classified as remote cognitive rehabilitation, computer assisted or computer based, cognitive rehabilitation (i.e. retraining) has gained popularity. Computer assisted cognitive rehabilitation aims to decrease client cognitive deficits through game-like programs (Chen, Thomas, Glueckauf, & Bracy, 1997). Several research studies have demonstrated improvements on neuropsychological measures after computer assisted cognitive rehabilitation. While positive results have been found, these improvements are time dependent and limited by small sample sizes (Chen et al., 1997). Because computer assisted programs teach clients on specific skills such as perception, attention, memory, and problem solving using specific games and scripted problems, clients often experience generalization problems to everyday life situation. Computer assisted cognitive rehabilitation differs from remote cognitive rehabilitation interventions due to the lack of interactions with clinicians, or the interactions are limited specifically to set up the computer programs.

A driving principle behind cognitive rehabilitation is the development and implementation of strategies requires repetition and practice (Schutz & Trainor, 2007; Rees, Marshall, Hartridge, Mackie, & Weiser, 2007). As a result, an individual could be expected to complete daily activities that support a strategy learned during a clinical interaction with a clinician. Another important aspect in cognitive rehabilitation is the concept of intervening in the natural environment. Research has shown individuals with cognitive disabilities experience difficulty transferring a skill learned in the clinic to everyday use. As a result, to promote the functional application of strategies, cognitive rehabilitation should be carried out in the environment where clients experience difficulty. Conducting cognitive rehabilitation through TR technologies, both videoconferencing equipment and learning management systems, may further promote skill acquisition and impact the retention and application of skills.

While several studies have evaluated the applicability of TR for the delivery of remote cognitive rehabilitation, and results have indicated that individuals with cognitive disabilities may benefit from remote cognitive rehabilitation services, there are no programs that replicate traditional face-to-face (FTF) cognitive rehabilitation that exist, to date. As a result, the purpose of this project was to develop, and evaluate a remote cognitive rehabilitation system. The development of the system needed to include a way to replicate traditional FTF meetings between a subject and a researcher, as well as a technology means to standardize daily activities that would reinforce repetition and practice.

4.2 MATERIALS AND METHODS

4.2.1 Requirements for a Remote System for Cognitive Rehabilitation

Prior to finalizing the components for the remote system, numerous intervention protocols and technology applications were reviewed. The original remote cognitive rehabilitation aimed to focus on problem solving, self-regulation, and self-awareness training using a manualized approach to delivering the intervention. Various cognitive rehabilitation protocols that focused on executive functioning interventions, self-instructional training for self-regulation, and problem solving were selected for evaluation (Cicerone & Gicino, 1992; von Cramon, von Cramon, & Mai, 1991; Lawson & Rice, 1989). After careful review of all protocols, these programs were eliminated due to lack of detail in the cognitive rehabilitation program, as well as standardization in the administration. Originally, it was envisioned that the Apple iPad or iPhone would be used to interact with the cognitive rehabilitation protocol and the content would be housed within a portal system that would link clients to a remote researcher who would manage the subject's rehabilitation content and monitor progress through the intervention. After review of the program needs, user designed portals would be too time intensive and limiting. Once a learning management system (LMS) that utilizes sharable content object reference model (SCORM) and Adobe Flash Player was identified as the appropriate resource to house the electronic cognitive rehabilitation content, the Apple iPad could no longer be used for the project. Many smart phones and tablets designed by Samsung, Blackberry, and Asus were discussed and several tablets were ruled out because they needed a dedicated data connection. As a result, tablets that could solely be used on a wireless internet connection were decided to be the best option.

The remote cognitive rehabilitation system was developed to provide cognitive rehabilitation services to individuals with cognitive disabilities who have limited access to trained clinicians. As a result, the system needed to be inexpensive and easy to use. The cognitive rehabilitation system was developed in two parts: a secure videoconferencing system and a remote cognitive rehabilitation application system. The *videoconferencing* system utilized the versatile and integrated system for telerehabilitation (VISYTER) (Parmanto, Saptono, Pramana, Pulantara, Schein, Schmeler, et al., 2010). VISYSTER was intended to replicate FTF meetings between the clinician and the client that were necessary to teach the memory program components and monitor progress. The *remote cognitive rehabilitation application* system utilizes a LMS and was designed independently, but to be used in conjunction with VISYTER to make up the cognitive TR program. Figure 2 illustrates the development process, while Figure 3 displays the steps taken in the process of developing the remote cognitive rehabilitation system.

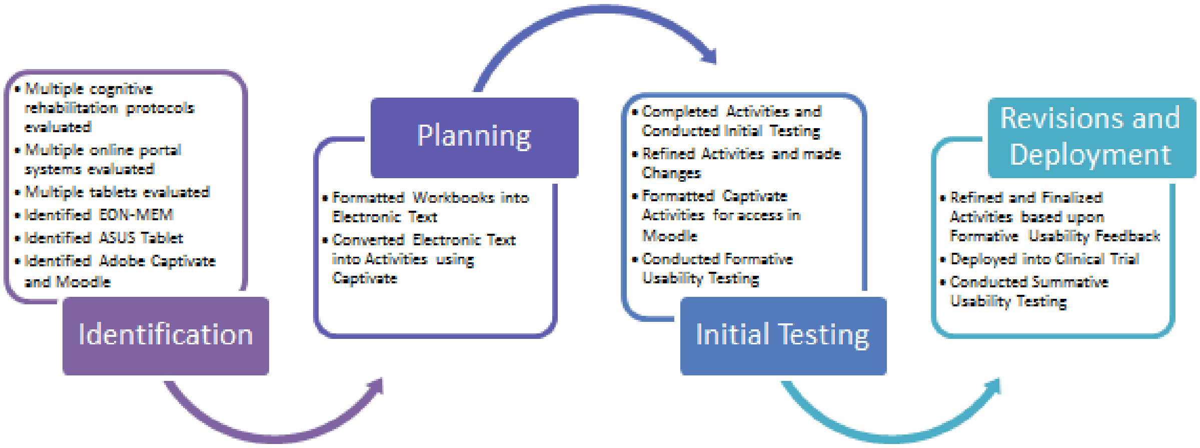

Figure 2. Development Flowchart

4.2.2 Identification

Upon ruling out several cognitive rehabilitation programs, as well as technology options, key systematic components were identified to be further developed for inclusion in the remote cognitive rehabilitation system.

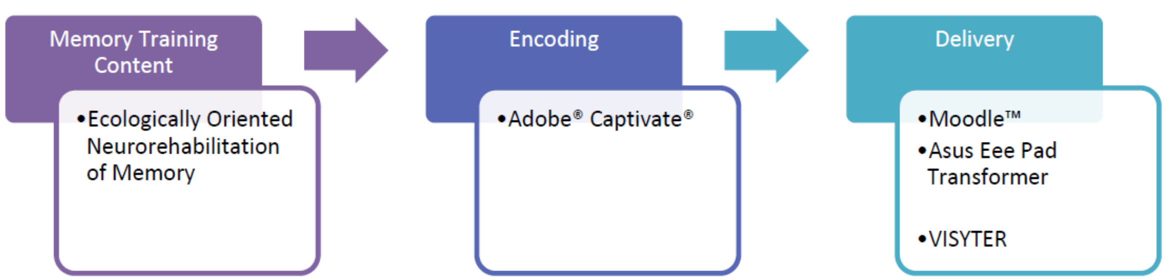

Figure 3. Steps to Finalizing Remote Cognitive Rehabilitation System

4.2.2.1 Ecologically Oriented Neurorehabilitation of Memory

The Ecologically Oriented Neurorehabilitation of Memory (EON-MEM) was developed by Anthony Stringer (2007). The EON-MEM protocol included weekly individual sessions and daily homework assignments to encourage learning between weekly sessions. The typical EON-MEM program is 21-weeks long and consists of 7 daily homework assignments to be completed between weekly clinical meetings. This protocol was shortened to consist of 9 weekly meetings with a researcher and five homework activities that were to be completed one assignment per day, each weekday between sessions. In the traditional program, each subject is provided a workbook that contains important information about the strategies they are learning and all of the activities they will complete during the course of their cognitive rehabilitation. A total of 35 individual activities are assigned to the subject. Each weekly session focuses on teaching the client application of strategies to help remember different types of information. During each weekly meeting, the subjects were instructed they were required to complete one activity each day and were note expected to complete more than one assignment per day. At the beginning of each weekly session, the researcher verifies the subject has completed the homework, if it was completed accurately, and they did one assignment per day based upon the self-report date at the top of each assignment. If a subject does not complete the homework, or has made errors, the researcher does not introduce new material and repeats the previous session to ensure the subject has an understanding of the material and can accurately apply the strategies. This cognitive rehabilitation program was identified as especially favorable to a remote TR application that would be delivered remotely. Each weekly session would be completed via VISYTER, with the researcher located at the University of Pittsburgh, Pittsburgh PA and the clients at the Hiram G. Andrews Center, Johnstown PA.

4.2.2.2 Development of the Remote Cognitive Rehabilitation System

LMS are web-based systems that allow individuals to share information with a group of people, usually educational information such as instructional information and class room activities, assignments and exams (Lonn & Teasley, 2009). LMS are also known as portals, instructional management systems, distributed learning systems, and content management systems (Coates, James, & Baldwin, 2005). Coates et al. (2005) also report several benefits for using LMS, including: asynchronous and synchronous communications, content development and delivery, formative and summative assessments, and class and user management. LMS are often used in distance education and have implications for distance practice.

4.2.2.3 Adobe® Captivate®

Adobe® Captivate® 5 was used to author the electronic format of the cognitive rehabilitation activities. Adobe® Captivate® software allows the building of interactive eLearning content through sharable content object reference model (SCORM). Adobe® Captivate® allows users to create quizzes to track subject responses to prompts and questions. Adobe® Captivate® 5 was chosen due to its simplistic approach and ease of learning, individuals without programming backgrounds can become proficient quickly using this software. After review of all Adobe® Captivate® features, quizzes were selected as the method for creating the electronic content. The standard paper based homework activities were used as the guide to create the electronic cognitive rehabilitation content. Each activity was individually transformed into an electronic format and tested multiple times to ensure the same cognitive demands were being place on the person completing the activities.

4.2.2.4 Asus Eee Pad Transformer

The Asus Eee Pad Transformer is a 10.1 inch Android tablet computer. The Asus does not have the ability to connect to a 3G data connection, but is enabled with a built in Wi-Fi module. While not having a 3G data connection plan limits the overall usability of the tablets because of the need to be connected to a wireless Internet connection, it was ideal for this project because it decreased the overall technology expenses. While it was originally planned to let the subject keep the technology (smart phone), when a tablet was selected, this feature was eliminated in an attempt to protect the tablets and ensure a longer shelf-life. As a result, it was decided the tablets would not leave the testing area and would have access to a dedicated Wi-Fi connection during the testing period. At the time of purchase, the Asus tablet cost approximately $370.

4.2.2.5 Moodle™

Moodle™ is a free, open source, course management system that allows people to build online learning applications and has become very popular among educators around the world as a tool for creating online dynamic web sites for their students. Because of its open source design, Moodle™ was identified as the best LMS for this project. Moodle™ was use to replicate the standard paper based homework assignments administration. Moodle™ was chosen as the LMS because it is free and the open source model allows for the modification of codes as needed. It also has free additional plug in components and is the most widely used LMS.

For this project, Moodle™ was calibrated for access using an Asus Eee Pad Transformer tablet PC to deliver the daily homework assignments to the clients remotely. The Eee Pad Transformer was identified as the ideal tablet because it utilizes the Android operating system, the screen size is large enough to accommodate the activities and was low cost and easily accessible for purchase. Apple's iPad was not a viable option because the activities were not compatible in an iOS operating system. Once the activities were created and verified to be accurate representations of the paper based versions, the activities were published in Adobe® Captivate® and loaded into the Moodle™ course.

Figure 4 displays the final remote cognitive rehabilitation components.

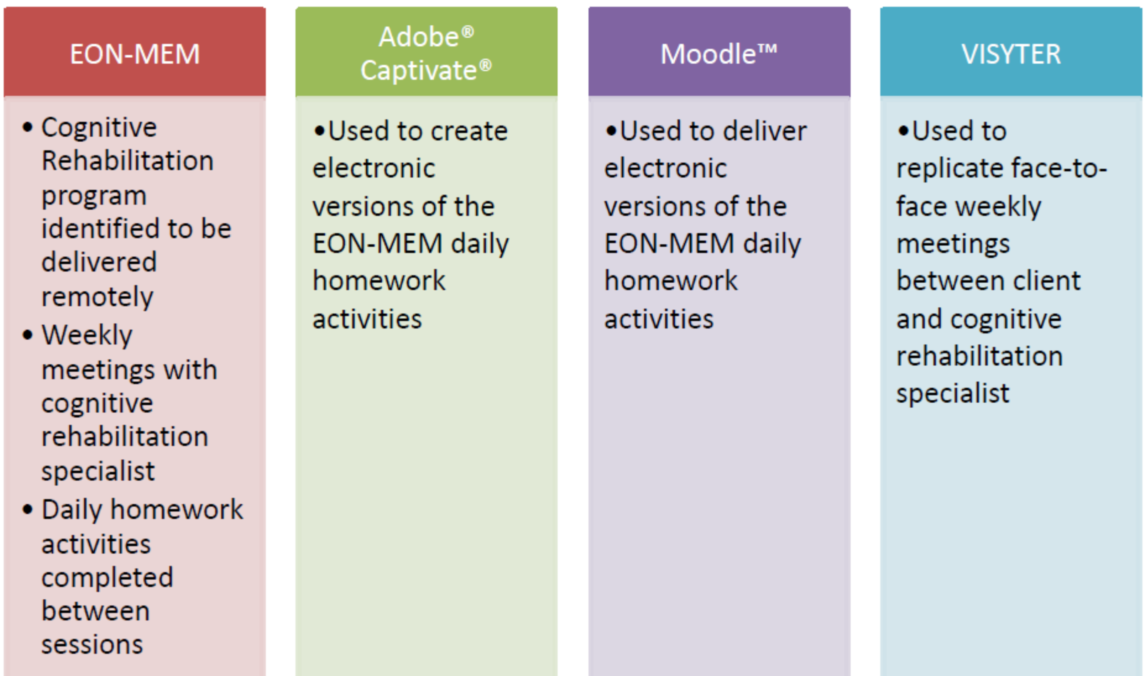

Figure 4. Final Components of Development of Remote Memory Training

4.2.3 Planning

Once the components were finalized, steps for transforming the individual components were taken to create a remote cognitive rehabilitation system. VISYTER was selected as the videoconferencing system to facilitate cognitive rehabilitation meetings between the researchers and the subjects. Because the cognitive rehabilitation content was being housed within Moodle™, no further VISYTER development needed to be completed. Unique log-ins and venues were created for each of the three researchers identified to conduct the remote cognitive rehabilitation sessions in a later clinical trial.

In order to transform the paper-based EON-MEM content, 30 patient workbooks were purchased. Each module was evaluated for its relevancy to the subject population for the clinical trial. When modules were deemed irrelevant, they were cut from the program until a 9-week program was developed. The program was also shortened to include five homework activities, instead of the seven in the original module. The decision to eliminate two activities from each module was made because the subjects would keep their tablet within the research office and would be available to the subjects Monday-Friday. The subjects would not be able to access the tablets over the weekend, so two activities needed to be eliminated. Thirty-five homework activities were selected for inclusion in the new 9-week EON-MEM program. Each electronic activity was individually created, utilizing Adobe® Captivate® and it's built in features. Discussions between the clinical researchers and the technical team were held for each activity to determine the most appropriate question type, layout, and structure logic. Once all activities were completed, they were initially tested within Captivate® and then uploaded into a shell Moodle™ course for further evaluation.

4.2.4 Initial Testing

Upon completion of all the activities and creating an appropriate cognitive rehabilitation course in Moodle, formative usability testing was completed.

4.2.4.1 Deployment of the Remote Cognitive Rehabilitation System

Each Asus tablet was Wi-Fi enabled and connected to a secure internet source. A total of eight tablets were purchased to be used in this large scale clinical study. Each tablet was assigned a unique user that would use the tablet to access their Moodle course. At the beginning of the cognitive rehabilitation program, all content is defaulted to be hidden from the subject until they are within a specific module. Once a module is completed, the content remains open so users can go back to view the previous activities. By using Moodle, it allowed researchers the ability to lock down, or hide, the assignments until the previous activity is completed. This also prevents individuals from completing all of the assignments in one sitting and requires them to complete one assignment a day. To ensure the content was available for the subjects, a researcher logs in at the end of every day to see if the subject has completed their homework assignment. If they had not completed the assignment, a new activity would not be opened. If they had completed the activity, the next activity would be opened for them to complete on the following weekday. As activities were made available, the list of assignments continued to lengthen. The subjects were instructed to complete the last activity in the list, as that would be the most recent activity made available and indicate the assignment they should complete. Because each client could move at different paces, each subject was enrolled into a unique course. If subjects were enrolled into the same course and they did not complete the required assignment, they may gain access to the next activity because the next available assignment would be opened for subjects who were on schedule and subjects may have access to content they are not ready for. As a result, subjects would be given access to assignments they are not scheduled for. Each subject enrolled was provided with a unique login and password, as well as an individual tablet. By providing individual courses, subjects cannot see other subjects' courses and can only see the information from their course. It also allows the researcher the ability to check clients' answers to see if they are completing activities correctly. If the answer is predetermined, the researcher can see if the client got the activities right, if the client is asked to enter free text, the researcher can read through the content each night or at a set time to see how the client is retaining and applying the information. This allows the researcher the ability to see how clients are doing, prior to their next session (if they have gotten the material). Certain activities require the subject to wait for a predetermined amount of time, specifically 10 minute and 30 minute waiting periods, before completing the last portion of activities. By creating the activity using Adobe Captivate, the waiting period was embedded into the assignment and the client would not be permitted to completing the activity before the waiting period has ended.

Session 2: Introduction to WOPR

Homework

Here is your homework. Do one homework assignment each day. Do not do all the assignments at once. You will learn the information best if you spread the work out over the week. Bring your completed work to the next session. It is okay to get help with this.

Assignment #1	Date Completed: _____/_____/_____

Draw a line from each WOPR letter to the WOPR word it stands for.

W Picture	O Organize	P Write	R Rehearse
W Write	O Rehearse	P Organize	R Picture
W Organize	O Write	P Rehearse	R Picture
W Rehearse	O Picture	P Write	R Organize

Figure 5. Paper Based Activity

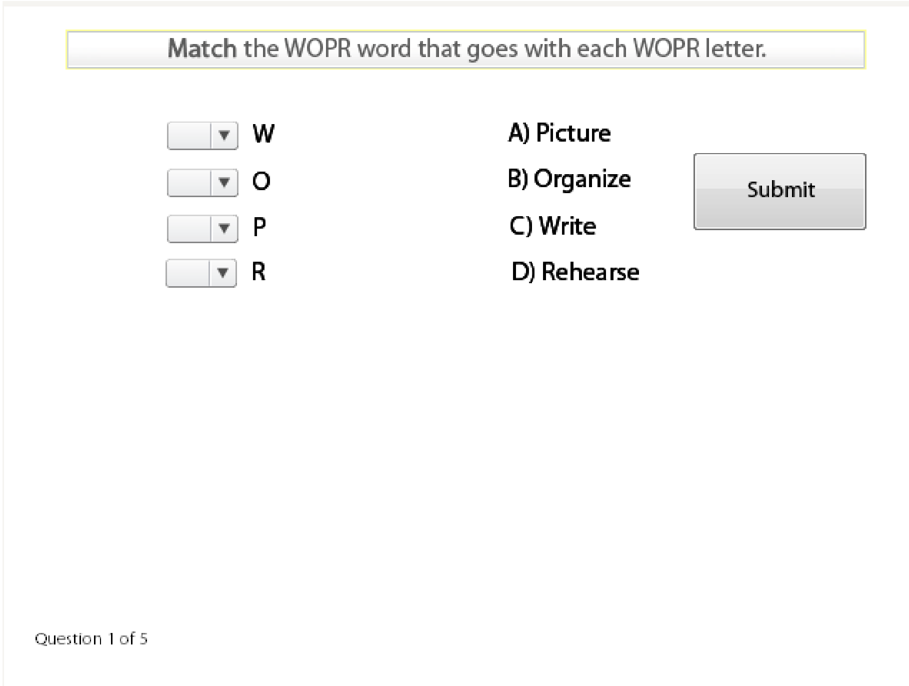

Figure 6. Electronic Activity – Not Answered

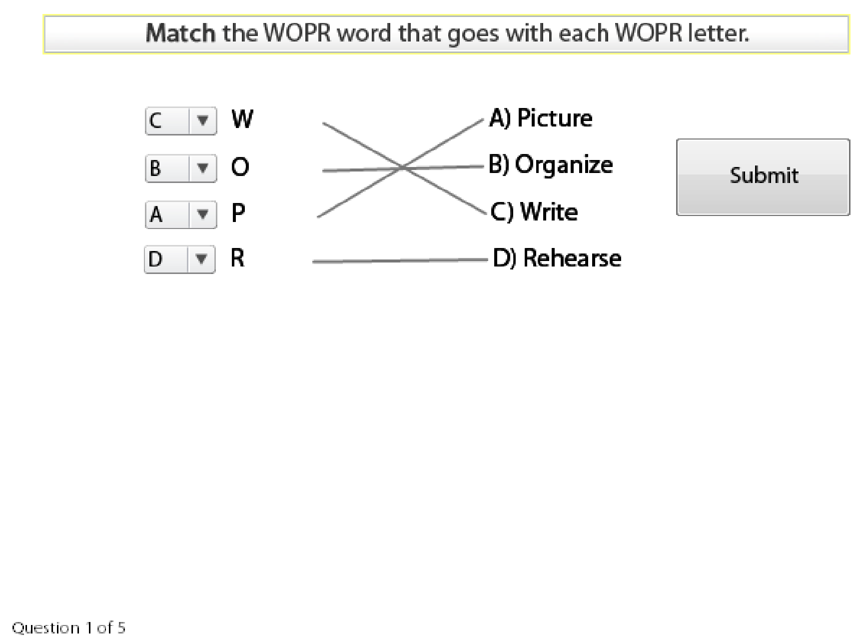

Figure 7. Electronic Activity – Answered

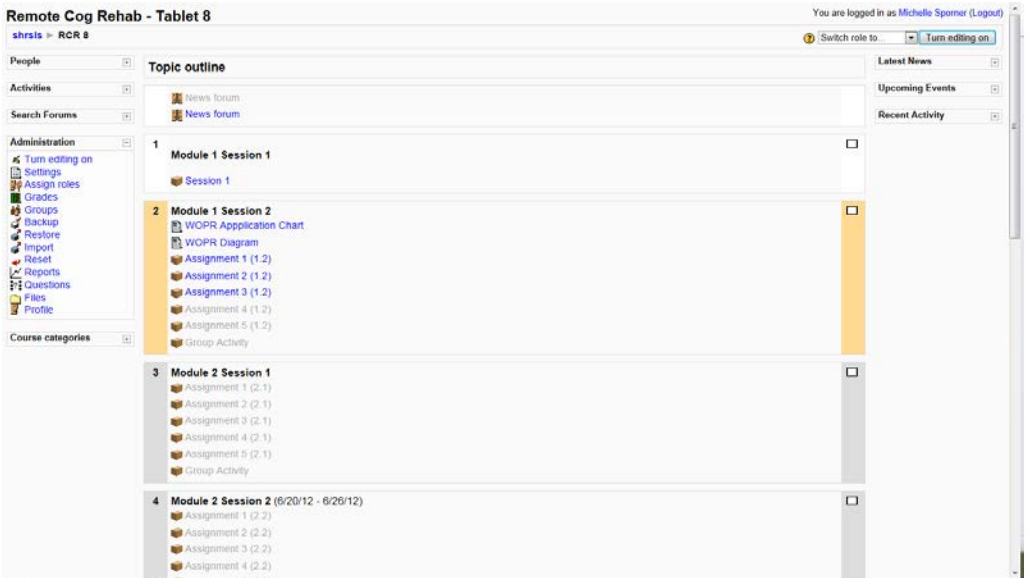

Figure 8. Researcher Moodle View

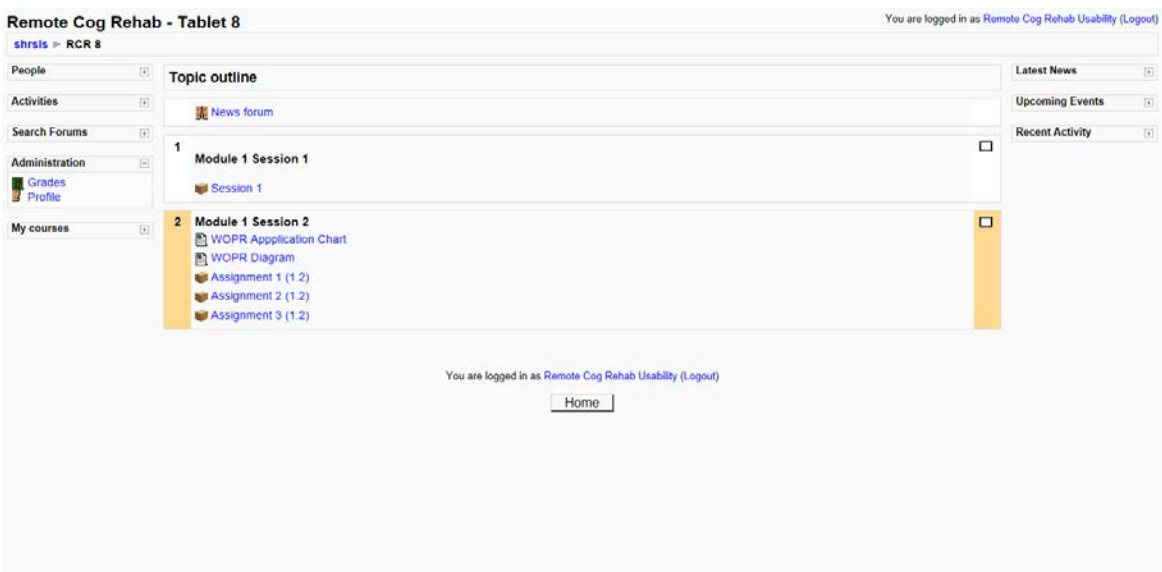

Figure 9. Subject Moodle View, with Content Hidden

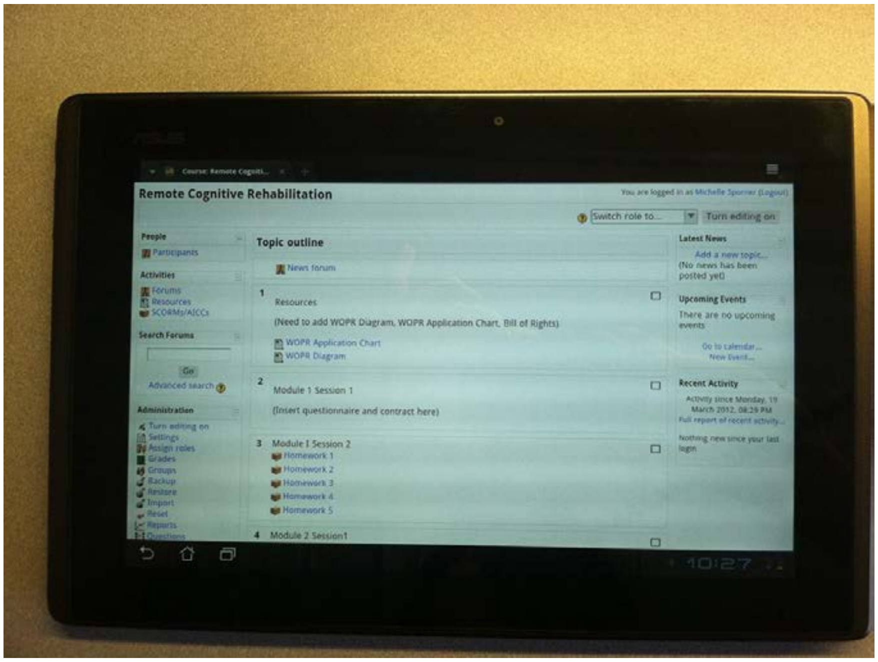

Figure 10. Moodle Accessed on Asus Eee Pad Transformer

4.2.4.2 Formative Evaluation of the Remote Cognitive Rehabilitation System

To evaluate the usability of the cognitive rehabilitation system, two types of usability studies were conducted on the system: formative and summative usability studies. According to Nielsen and Mack (1994), the goal of a formative usability study is to identify usability issues and concerns and to improve the overall usability of systems by addressing these problems. The methodology used in this study is the "cognitive walkthrough" usability inspection (Nielsen & Mack, 1994). As designed, a cognitive walkthrough involves either one or a group of evaluators inspecting a user interface by viewing a set of activities and evaluating understandability and ease of learning. In this project, four clients with cognitive disabilities currently enrolled in a group cognitive rehabilitation program, as well as four experienced cognitive rehabilitation clinicians completed four cognitive rehabilitation activities accessed on the Asus tablet to elicit usability feedback regarding the interface and overall usability of the tablet activities. After subjects completed all cognitive rehabilitation activities, the Telehealth Usability Questionnaire (TUQ) was used to structure an interview that focused on the subjects' current needs, preferences, and goals to be achieved from using the system and their desire to use TR services again. The TUQ is a tool designed by the University of Pittsburgh and is based upon a number of different usability questionnaires, including the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 1995). The TUQ asks subjects to respond on a 7-point Likert scale from disagree (1) to agree (7). Higher scores (means) on the TUQ indicate a higher degree of usability. Average scores from each question of the TUQ were computed for clinicians and the clients. The TUQ also produces an overall usability score, as well as Usefulness, Ease of Use, Effectiveness, Reliability, and Satisfaction constructs. Overall scores and construct scores were computed by taking the average of total questions answered, as well as specific questions that reflect each construct. Questions reflecting Usefulness and Effectiveness construct scores were not asked, and as a result, were not computed for formative usability. Institutional review board approval was obtained through the University of Pittsburgh prior to the formative usability study.

Construct scores indicate an overall high degree of usability as rated by the clients and the clinicians. The range of scores for Ease of Use (4.83-7.00), Reliability (4.00-7.00), Satisfaction (4.00-7.00), and Overall TUQ (5.17-6.92) are all above the median score (4.00 out of 7.00) and indicate that both clients and clinicians were mostly satisfied with the system.. The overall mean usability construct score was high for both clients (6.23) and clinicians (6.10), indicating an overall high level of usability. Mean results and the score ranges for the formative TUQ items are reported in Table 4.

Table 4. Formative Telehealth Usability Questionnaire Results

TUQ Question **Mean (Standard Deviation)**	**Minimum**	**Maximum**	**Clients (n=4)**	**Clinicians (n=4)**
It was simple to use this system	5.00	7.00	6.25 (0.96)	6.50 (1.00)
It was easy to learn to use the system	4.00	7.00	6.25 (1.50)	6.50 (0.58)
I believe I could become productive quickly using this system	6.00	7.00	6.75 (0.50)	6.00 (1.16)
The interface of this system is pleasant	4.00	7.00	6.25 (1.50)	5.75 (1.26)
I like using the interface of this system	4.00	7.00	5.75 (1.50)	5.75 (1.26)
The organization of the interface is simple	5.00	7.00	6.50 (0.57)	5.75 (0.96)
This system has all the functions and capabilities I expect it to have	5.00	7.00	7.00 (0)	6.00 (0.82)
I find telehealth an acceptable way to receive healthcare services	5.00	7.00	6.25 (0.96)	6.50 (0.58)
I will use telehealth services again	4.00	7.00	6.00 (1.41)	6.50 (0.58)
Overall, I am satisfied with this telehealth system	5.00	7.00	6.25 (0.96)	6.25 (0.96)
Ease of Use	4.83	7.00	6.29 (0.67)	6.04 (0.91)
Reliability	4.00	7.00	5.75 (1.19)	5.88 (0.75)
Satisfaction	4.67	7.00	6.17 (1.11)	6.42 (0.69)
Overall TUQ	5.17	6.92	6.23 (0.57)	6.10 (0.75)

*TUQ=Telehealth Usability Questionnaire; Min=Minimum; Max=Maximum

The range of scores for the clients and the clinicians was generally high, with the lowest scores receiving a four. The factors that were rated the lowest were the ease of learning the system, the interface, and likelihood that the subjects would utilize TR services again in the future. The mean scores for the clients ranged from 5.8 to 7.0, while the range of scores for the clinicians ranged from 5.8 to 6.5.

Two of the four clients provided open ended feedback from the system. The first client stated “I could see myself using this in future tasks”. The second client did not provide direct feedback to make improvements to the system, but was concerned with the accessibility for individuals with different disabilities including sensory impairments and fine motor control.

Each of the clinicians gave specific feedback regarding each assignment, including what they liked about the system, what difficulties they had completing the activities, and what they would change to the system. Clinician Four stated "Very cool system. I think clients will like using it and then be more motivated to complete assignments." Clinician One stated "This system would be beneficial for clients in rural areas who have a difficult time receiving services." Open ended feedback results from the clinicians can be found in Table 8, while open ended feedback from the clients can be found in Table 9.

4.2.5 Revisions and Deployment

Upon completion of the formative usability testing, the researchers made revisions to the each activity in Adobe® Captivate®. Additional evaluations were completed prior to uploading the new activities back into Moodle™. Once all revisions were completed, the cognitive rehabilitation system was deployed into a clinical trial and additional usability testing was conducted.

4.2.5.1 Summative Evaluation of the Remote Cognitive Rehabilitation System

Subsequent to the formative usability study, and the resulting improvements to the electronic activities, a summative usability study was conducted on the finalized remote cognitive rehabilitation system. For individuals with disabilities, the main purpose of rehabilitation research is to produce valid conclusions regarding the relationships among variables, specifically in the lives of people with disabilities (Bellini & Rumrill, 1999; Hennessey & Rumrill, 2003). As a result, a subsequent goal is that changes achieved during rehabilitation research are due an intervention and not due to a random factor or chance (Gresham, MacMillian, Beebe-Frankenberger, & Bocian, 2000). In order to achieve this second goal, rehabilitation interventions must have fidelity (Sterling-Turner, Watson, & Moore, 2002). Treatment fidelity, also known as treatment integrity, refers to the uniformity, consistency and ability to replicate treatment delivered in a particular setting (Hennessey & Rumrill, 2003).

The purpose of the summative usability was to evaluate the fidelity of the electronic activities, compared to the original paper based versions. Homework activities were chosen from each module for summative evaluation based upon the demands of the activity. As a result, assignments from each module were evaluated to identify the demands of the assignment. Two different assignments from each module were picked. Some modules have one base homework assignment that varies only by the number or the content being presented for memory. One homework activity was chosen from these modules. A total of 10 homework activities were identified for the summative usability study. Table 5 displays the activities chosen for summative usability testing.

Table 5. EON-MEM Assignments Selected for Fidelity Testing

Module	Homework Activity
Module 1 Session 2	Homework 1
Module 1 Session 2	Homework 4
Module 2 Session 1	Homework 1
Module 2 Session 1	Homework 5
Module 2 Session 2	Homework 1
Module 3 Session 1	Homework 1
Module 3 Session 1	Homework 5
Module 3 Session 2	Homework 2
Module 3 Session 2	Homework 5
Module 4 Session 1	Homework 1

A brief introduction to the EON-MEM was provided to the clinicians. Paper copies of each activity, along with a tablet that was set up to access the activities through Moodle were provided to the subjects. Fidelity questions were administered to the subjects after they completed every paper based and the corresponding electronic versions of the same activities.

The subjects were asked to rate each activity on the degree to which the electronic activities compared to the paper based activities. These factors included the homework activity, the timing, instruction delivery, and the alteration or changes to the demands of the task. Homework activity reflected the overall activity and the questions presented to the subject. The item regarding the level of alteration or change in the demands of the task included if the activity was harder or easier on the tablet, or did it require the subject to utilize a different set of cognitive functions. Each item was rated on a 7-point Likert scale from minimum difference (1) to maximum difference (7). Lower scores indicate a higher degree of fidelity to the original activities. The TUQ was also administered to the subjects after completion all of the homework activities. Overall scores and construct scores were computed by taking the average of total questions answered, as well as specific questions that reflect each construct. Questions reflecting Usefulness and Effectiveness construct scores were not asked, and as a result, were not computed for summative usability. Institutional review board approval was obtained through the University of Pittsburgh, prior to the summative usability study. Seven experienced cognitive rehabilitation clinicians participated in the summative usability study.

Results from the fidelity questions indicated that overall, there was a moderate level of fidelity to the paper based activities. The overall mean fidelity for the homework activities was 1.81±1.63 and the instruction delivery was 1.56±1.20, which reflect a high level of fidelity for the actual assignments. The overall mean timing was 2.50±1.67 and the demands of the tasks were 2.34±1.44. Several activities scored better on the activity, but received high scores for other aspects of that assignment. For example, Homework 4 from Module 1 Session 2 received the minimum degree of change (1.14), however scored a 3.00 on the degree of change in timing.

Activity 1 from Module 1 Session 2 received a high level of change in the demands, compared to the other assignments. A breakdown of the means for each activity can be found in Table 6.

Problems with two activities were also identified during the fidelity testing. As a result, Module 2 Session 1 Homework 5 and Module 3 Session 1 Homework 5 were not rated by each clinician. The activity from Module 2 Session 1 requires the subject to listen to sound on the tablet. During testing, the sound did not always play properly or at all for two subjects. As a result, they could not answer each of the questions. Additionally, questions on the second half of the activity for Module 3 Session 1 Homework 5 were incorrect and part of the previous activity. As a result, subjects could not complete this activity, although some still completed the rating. Table 6 details the summative usability results for each specific activity tested.

Table 6. Summative Usability Results

	Homework Activity	Timing	Instruction Delivery	Alter or change the demands of the task
Mod 1 Session 2 HW 1	2.29 (1.70)	2.71 (1.98)	1.00 (0.00)	3.00 (1.00)
Mod 1 Session 2 HW 4	1.14 (0.38)	3.00 (1.00)	1.43 (0.54)	1.86 (1.46)
Mod 2 Session 1 HW 1	1.00 (0.00)	2.57 (2.07)	1.43 (0.54)	2.14 (1.86)
Mod 2 Session 1 HW 5	1.33 (0.52)	2.83 (1.84)	1.33 (0.52)	2.17 (0.41)
Mod 2 Session 2 HW 1	2.29 (1.80)	2.29 (1.60)	2.00 (1.53)	2.67 (1.75)
Mod 3 Session 1 HW 1	1.14 (0.38)	1.86 (0.90)	1.00 (0.00)	1.57 (0.79)
Mod 3 Session 1 HW 5* **	5.80 (2.68)	2.83 (2.86)	3.00 (3.10)	3.17 (2.56)
Mod 3 Session 2 HW 2	1.43 (0.79)	2.86 (1.68)	1.71 (0.95)	2.29 (0.76)
Mod 3 Session 2 HW 5	1.29 (0.488)	2.71 (1.70)	1.58 (0.79)	2.43 (1.72)
Mod 4 Session 1 HW 1	1.43 (0.54)	1.43 (0.79)	1.29 (0.49)	2.29 (1.25)
Overall Mean	1.81 (1.63)	2.50 (1.67)	1.56 (1.20)	2.34 (1.44)

Overall results from the summative usability TUQ indicate that clinicians found the tablet and the LMS as satisfactory and as a usable modality for cognitive rehabilitation. Clinicians rated the pleasantness of the interface (5.71±1.13), the comparability of healthcare visits provided through TR (5.71±1.50), and that they liked using the system (5.86±0.90) as the lowest. Although clinicians rated the comparability of healthcare visits as lowest, they did however rate that telehealth was an acceptable way to receive healthcare (6.43±0.54), as well as they would use telehealth services again (6.43±0.54) as the two highest features for the overall system. Additional TUQ scores for the summative usability outcomes can be found in Table 7.

Table 7. Summative Telehealth Usability Questionnaire Results

TUQ Question **Mean (Standard Deviation)**	**Minimum**	**Maximum**	**Clinicians (n=7)**
It was simple to use this system	5	7	6.14 (0.90)
It was easy to learn to use the system	6	7	6.29 (0.49)
I believe I could become productive quickly	5	7	6.14 (0.69)
The interface of this system is pleasant	4	7	5.71 (1.13)
I like using the system	5	7	5.86 (0.90)
The system is simple	6	7	6.29 (0.49)
This system has all the functions and capabilities I expect it to have	3	7	5.71 (1.50)
I think visits provided over the system are the same as in person	4	7	6.00 (1.00)
I find telehealth an acceptable way to receive healthcare services	6	7	6.43 (0.54)
I will use telehealth services again	6	7	6.43 (0.54)
Overall, I am satisfied with this telehealth system	5	7	6.29 (0.76)
Ease of Use	5.3	7	6.07 (0.69)
Reliability	3	7	5.36 (1.22)
Satisfaction	5.7	7	6.38 (0.59)
Overall Score	4.9	7	6.00 (0.72)

Table 8. Qualitative Formative Usability Feedback – Clinicians

ID	User Group	Activity1	Activity2	Activity3	Activity4
CL1	Clinician	Difficult drop down menu - got stuck and had to press answer a few times	Several slides had missing audio (13 and 14). One activity we couldn't hear, need repeat button. Use return to answer instead of scrolling down. Screen (keyboard) popped up instead of having to search for it.	Have to have a lot of memorization to complete. It would be nice to have the chart and click on the appointment to fill in the time. Is there a way to make this assignment into a table?	Tablet like activity 3, if a visual person, to fill out so they don't have to worry about spacing, commas, etc with writing out the categories.
CL2	Clinician	Really hard to get the buttons. Have to scroll to see the directions and the submit button, would be better if it's on one page	Delay? Might have been intentional. Nice because it's all on one screen, didn't have to search the screen for the keyboard	Really hard to remember what the appointments were. A lot of information to remember. Not clear how to do it. Directions and box were confusing.	Like that it counts down. Directions were a little hard, but it might be because I didn't do that in my own memory training
CL3	Clinician	Works fine as an activity. I like that it drew a line to the word. Would be nice if they could actually draw the line. A little bit awkward size to scroll to see the answers and the submit button. Make selection box bigger - wasn't sure where pointing and might cut down on error	Hit submit, didn't fully enunciate the word. Keyboard didn't come up when tapped the text box. Have number there as a backup (in writing, visual cue). Can you repeat it?	Hit the keyboard and it jumped to the bottom of the screen and you can't see what you're typing. (Clinician rotated it to portrait view during testing). More difficult. Input like iPad/iPhone appointment to keep all information - start, stop time, location, etc. More schedule like format to make it more transferable	Some of the categories were tough - food and electronics were good but I rushed through it. Maybe if there was a layout they could follow or practice with.
CL4	Clinician	Instead of "a", "b", "c", "d", could the pull down menu say the actual word. That would take out the cognitive demand of trying a letter to a word	#9 - I couldn't get the keyboard to come up. Kept touching the text box, but nothing happened. Also couldn't submit and had to exit the activity.	No Feedback	Wasn't sure when it was done. The others had a nice "Return tablet to clinician cue

Table 9. Qualitative Formative Usability Feedback – Clients

ID	User Group	Activity1	Activity2	Activity3	Activity4
C1	Client	Liked it better than paper. More hands on - makes it easier to use	Interesting. Reading it back to you made it easier to understand than reading it yourself	Little tougher - trying to remember the times and the appointment names. But it's the same with paper.	Very different, easier than paper. Could work with that and is better than paper
C2	Client	It's good. Its better (modern technology). No changes	Better than paper - everything's better than old school. No changes	Good. Made me think more because we weren't allowed to go back. No changes	Went pretty good. No changes
C3	Client	Like paper better, it's a pain. Don't have to rely on internet for paper. But I did like it.	Was alright, wasn't too hard, wasn't too easy. No changes	"Good" - middle between easy and hard. Touch screen hard because it didn't bring up the keyboard	No Feedback
C4	Client	I think it's nice, fun. I don't like pencil and paper (pencils break and markers bleed through) I like computers. For blind people, it should say the word	Move submit button up so you don't have to scroll. I like it. Says the word, but for deaf people it should show the number as well. Make it so you don't have to scroll backward/forward. But if you make a mistake, make it so you can fix it	Very god. Should be able to get a hint, reshow the appointments without the times so you don't miss an appointment. Bar so you could select how long it will take so it can compute the time. How long the appointment will last, won't let you schedule two appointments at the same time	Like it, no changes

Table 10. Qualitative Summative Usability Feedback Activity 1-5

ID	Mod 1 Session 2 HW 1	Mod 1 Session 2 HW 4	Mod 2 Session 1 HW 1	Mod 2 Session 1 HW 2	Mod 2 Session 2 HW 1
SU1	The demands of the task change because it becomes frustrating to wait for the tablet to catch up. This could lead to incorrect answers	Timing of the questions appearing and of the keyboard showing up is different	Demands increase because of the timing issues and if the touch screen doesn't work		This one is different (harder) because you can't reference the # like you can in the workbook. You **REALLY** have to memorize it.
SU2	The electronic activity may slow down the rate you can complete the assignment as it takes longer to load. However, the homework's are very similar	Slower to complete the electronic because you are waiting on the system.	No difference in the homework activities, however timing is slower on the tablet.	Didn't work	On paper, you can look back at the number to remember chunks and create pictures - you have to remember the number from the beginning on the tablet
SU3	I think it changes the demands because it adds in a variable - instead of w--> write, w-->write--> A. Not actually drawing lines, more fine motor skills required on tablet	Timing - takes longer on tablet - might be good to slow clients down and make them think. Instructions - type, not write	Instruction delivery - write not type	Timing and Instruction delivery - takes a little longer on the tablet - responses are typed, not verbalized. Demands of task - written vs. verbal responses. Can't repeat word on tablet. No social interactions requirements on tablet - this may make it more or less reinforcing?	When chunking and describing images on tablet, put separate space for each chunk. I only put one chunk and couldn't go back to pick. Delivery is better - more consistent with tablet. How do you know they will actually work with someone on paper? Timing is BETTER with tablet - enforces 30 minute delay
SU4	Adds variable w-w but electronic w - (A, B,C,D). A little harder	Same activity. Slower on tablet. May require tiny bit more thinking but not much	Slower only difference	Didn't work so could not use it	#4 written gives you space to write out each separate chunk with image. Tablet does not. Should separate them out
SU5	Requires somewhat different motor skills to use. Tablet requires finer selection than paper	Client is forced to slow down on the tablet, possibly encouraging them to consider the word rather than only matching the first letter	Could not reference previous answers on tablet as you could on paper	Tablet required typing responses which may be more challenging to certain clients than verbalizing	

Table 10. (continued)

SU6	Matching letter (WOPR) to word, then alphabetical letter selection (ABCD). Electronic took a little longer to complete	Paper - recall letter and write. Electronic - view selection, find, and type. May be benefit to slowing process down. Electronic version - actually reading word before selecting letter. Paper version - found it easiest and quickest to simply look at the first letter and write it down		Timing differs because user must type instead of verbal response. Instruction delivery - electronic version may be more efficient (human may read the answer word by mistake)	Chunking images/words (electronically) in the small space is difficult and may need revised or altered
SU7	Slower using the drop down menu. Easier to see whole field with paper	Slower - can submit too soon if you lose sequence of task	Slower, but not different clinically	Timing and typing, but not very different	Combination of words, images, and numbers was confusing

Table 11. Qualitative Summative Usability Feedback Activity 6-10

ID	Module 3 Session 1 HW 1	Module 3 Session 1 HW 5	Module 3 Session 2 HW 2	Module 3 Session 2 HW 5	Module 4 Session 1 HW 1
SU1		The final question was different		The demands changed because you actually have to remember the items - using the notebook is easier to cheat	
SU2	Timing slower on electronic	Wrong assignment	Timing is slower - forced to wait the 30 minutes (which is good!)	Electronic is a little slower as you are waiting on the system. Forced to wait the 10 minute delay.	They are both similar! Timing is not an issue for this one.
SU3	This one was very similar	Appointments were different on tablet. Have opportunity to write out images on paper - can't do that on the tablet	Instructions - chores are already presented in pairs on tablet. Typing instead of writing. Timing - enforces 30 minute delay. Other: Paper has lines - one chore per line and tablet you have to write everything on one line	Enforced the 10 minute break on tablet - I didn't even notice it on paper. Wish there were several lines to enter data into, not just one	Nice to be able to see rules when you make your acronym (on paper). Need more space for typing.
SU4	Same	7 on activity different because of wrong prompts. 4 on demand of task because you can write out the images so you learn it better	HW Activity: Same; Time: Same; ID: Different (3) because listed in blocks on tablet - similar to each other. Made it easier to visually pair together. A/C: Tablet is easier because of layout	ID: Super center image on tablet. Words grouped together in table - makes it easier to group and visualize. A/C: easier because of the chart on the table	On the paper, you can create acronyms and acrostics with rules at the top for reference. On the tablet, when you switch the page to write the acronym, you can't reference the rules anymore. Makes it harder
SU5	Paper style allows you to reference previous answers	Paper allows you to writ out images - though instructions do not state. This could be done on a post it on tablet	Paper task allows you to visually organize tasks before re-writing them in order	Paper allows you to visually categorize items which the tablet does not	Paper assignments lets you look back at the rules and your acronym which tablet switches to another page - tablet may be more difficult as a result
SU6		Can write or draw on paper version	Electronic visual displays/coloring - basically orders the activities into categories for the user	Electronic visual display/coloring appears to categorize for the user	Electronic version - user must click to next slide and not reference back to develop acronym
SU7	Need a strategy to begin task and then keep using it for consistency		Less different - Except not having all visual info present on paper	Timing is slower. Can't sketch if that helps you	Not very different - writing mode in both - less need for pictures

Open ended feedback for each activity was also solicited. The majority of comments for the activities was in response to the timing on the tablet was slower than using the paper and pencil. Although it took longer to complete the activities on the tablet, many clinicians stated that slowing the clients down could be an additional benefit as it forces the client to slow down and think about what they are working on. Specific feedback for each activity can be found in Tables 10 and 11. Additional feedback on the overall system, as well as potential confounds when using the tablet can be found in Table 12

Table 12. Qualitative Fidelity Feedback

ID	Overall	Confounds
SU1	The demands are greater because - 1. Participants can't cheat as easily like they can in the notebook and 2. if the tablet isn't responding quickly, the participant may get frustrated	See overall responses. Timing and frustration because of that. Can't go back and review. Can't skip around. Not easy to access notepad while in the virtual classroom - having the notebooks is much easier to jot down notes. Some may people learn better and memorize things when they are hand-written versus typing.
SU2	Electronic activities place an increased demand on the participants (not being able to look back at the paper to recall information). However, this could be a positive thing! Not allowed to look back (easily) at earlier info to review	If someone is not comfortable with or struggles with the tablet and the remote sessions, this may factor into differences
SU3	Less space to write, required to wait during time delays, sometimes info is presented differently.	Fine motor skills?
SU4	See other comments (at times - layout)	Not writing on tablet if people benefit from actually writing
SU5	Electronic activities separate tables more than paper-based. Electronic does not allow you to reference your previous answers	Difficulty using technology (i.e. typing) may make electronic activity difficult or frustrating
SU6	See other comments	Time and display
SU7	Can see visual field with paper. Paper is faster - delay on tablet may affect memory	Memory delay with tablet

4.3 DISCUSSION

Results of the formative and the summative usability studies showed that the overall reception of the remote cognitive rehabilitation activities was positive. With respect to the formative TUQ, both the clinicians and the clients rated each item as they generally agreed to the usability features. Formative usability results indicate that both clinicians and clients had a high level of satisfaction with the system. Clinicians however, rated they liked using the interface of this system lowest (average of 5.75 out of 7). Clinician's mean Overall TUQ scores on formative usability (mean 6.1) and summative (mean 6.0) usability indicate a high level of usability for the TR system. In general, the results from the TUQ indicate that they liked using the system and were pleased with the features.

Clinicians provided more in depth feedback regarding each assignment, including what they liked about the system, what difficulties they had completing the activities, and what they would change to the system. With respect to the overall usability of the system, one clinician stated "Very cool system. I think clients will like using it and then be more motivated to complete assignments." Another clinician stated "This system would be beneficial for clients in rural areas who have a difficult time receiving services." One clinician also had difficulty completing one of the activities and provided feedback that "I had one minor problem when I couldn't enter the text box. Had to leave the assignment." Additional usability feedback included making the text directions smaller on the screen, reduce the need for scrolling within the screen, and add additional opportunities to review answers on activities. A full list of the feedback provided by the clinicians is provided in Table 8, while feedback from the clients is provided in Table 9.

Although the feedback was generally positive, some difficulties were observed and required modifications to the system. One of the main comments regarding the look of the activities was the spacing was too long, so the subject had to scroll to find the submit button on each activity. Every activity was re-spaced to fit on the tablet screen with minimal scrolling. Paper based activities that include charts, were modified to better replicate the paper based activity (e.g., Module 3, Session 1). While these changes were made to the system, some modifications could not be made due to limitations of Captivate. Captivate presents one question on one slide, so it was not possible to ask multiple questions on one slide. When the clinicians were typing, it was noted that it would be more helpful if they could hit the enter button on the on-screen keyboard. This functionality was not possible with the Asus tablet. The touch screen was also sensitive with the input mechanism for answering questions on one activity. Although these were noted as possible changes the subjects would like to have seen, it did not prevent any subject from being able to complete the activities.

Results from the summative usability TUQ also indicated the clinicians were overall satisfied with the tablet and found the system to be usable. During summative usability testing, it was discovered that one of the activities had the correct introduction questions, but the wrong follow up questions after the time delay. Module 3, Session 1, Homework 5 was fixed to match the paper based activity.

4.3.1 Fidelity

Overall, the results of the summative usability study indicate a moderate level of fidelity to the original paper based activities and reinforce the expectations of treatment fidelity, including consistency and the ability to replicate treatment delivered in different settings (Hennessey & Rumrill, 2003). To support treatment fidelity, the EON-MEM was selected as the intervention because of its manualized approach to administering and supporting client generalization through the patient workbook. While the fidelity of the original activities was acceptable, there were some problems with the electronic activities. During the creation of the electronic activities, it was observed that some activities do not translate easily into an electronic format, which is a limitation of Adobe® Captivate® and the SCORM created. On the paper based activities, clients have the ability to look back at what they have already completed, which allows them to verify their answer. In Adobe® Captivate® 5, only one question can be presented on a single slide, thereby limiting the amount of visual stimuli that is presented during a specific period. Additionally, there is an inherent glitch within Adobe® Captivate® that prevents users from scrolling backward. When the clients click back, it prevents them from moving forward again. As a result, clients did not have the ability to scroll back to see what they have already done, or to verify understanding. Additionally, when audio files are presented to the client, Adobe® Captivate® did not provide the ability for clients to replay the audio. This is different from FTF when a client can ask a facilitator to repeat their prompt. Several of the homework activities were similar, while others were quite different. For example, Module 2 Session 2 Homework 1 forces the client to memorize the number and prevents them from looking back at their answers, which decreases the ability of the client to simply copy the number over to the next question. Additionally, on the paper, clients may skip the 30 minute delay, either because they did not read the directions or because they chose to not wait the time. However, on the tablet, clients cannot move to the last recall question until the 30 minutes have passed. Timing was also an area that the clinicians felt were different between the tablet and the paper activities. While timing could be an issue when there is a lag in the tablet moving to the next question due to internet connectivity, other times it recognized that slowing clients down forces them to concentrate on what they are working on and to make them think about each question. It was also recognized that several of the activities were harder on the tablet because the clients have a limited ability to make notes as they do on the paper methods.

4.3.2 Implications of LMS for Cognitive Rehabilitation

There are several benefits to using LMS in a cognitive rehabilitation program. Because activities can be hidden to prevent people from working ahead, it can help prevent individuals from becoming overwhelmed with too much content at one time. It also ensures people only do one activity at a time and promotes subjects to work on activities at a clinically appropriate pace. Using a LMS also allows for continued follow-up between sessions, as opposed to doing all activities in one sitting and not having to think about the strategies/content until the next session. Since LMS are designed for accessing material by both instructors and students, it has a monitoring component as one of its core features. As a result, it allows for remote monitoring of client progress. For example, if a person has not worked on any activities for several days, the researcher can contact the person to remind them to work on the activities to get the most from the cognitive rehabilitation program. Another potential benefit is embedding time delays into activities. For instance, by not allowing subjects to move on to answer a question prior to the end of a waiting period, it allows a better presentation of how the person completed the activity.

Aside from the ability to keep activities hidden from the clients until they are ready to work on them, LMS also allow for an automated control of content to the client while allowing for a dynamic activity. Having the ability to complete activities on a tablet PC, or on a desktop computer, allows for a customizable cognitive rehabilitation program. While this project was completed using a very structured cognitive rehabilitation program, other activities could be transformed into SCORM and delivered through a LMS, compared to a binder of activities or a spiral bound notebook with predetermined activities. This method would give clinicians a way to meet with clients to determine their needs. Once they have completed a needs assessment, the clinician could pick modules they deem important for the client and load them into a LMS to create a unique program for that client. Additionally, using a LMS like Moodle, you can enroll a client into a program with their own, personal email address.

While there are many benefits to using a LMS in cognitive rehabilitation, there are a few potential drawbacks. With certain activities, it can sometimes be difficult to determine client responses. With cognitive rehabilitation, strategies are individualized, which means there is not always a predetermined right or wrong answer. As a result, during the design of electronic activities, researchers may not always be able to make predetermined responses and will have to find each individual response during the clinical application. Depending on the SCORM development, clinicians have to search through lines of code to find the client's response. Additionally, using an LMS requires additional staff resources and time for staff. A clinician needs to check the LMS daily to ensure completion of the appropriate activity and to then open the next activity for each client, although time needed to complete the check is quite minimal. Additional time is needed to check through the answers and see if the clients are applying strategies appropriately. This is an advantage, however, as it allows the clinician to better prepare for the next session, prior to meeting with the client. The clinician can see where clients may be experiencing difficulty and allot more time for the client and tailor the session content prior to meeting.

4.4 CONCLUSION

LMS are widely used in education, but this new clinical application allows for a greater use beyond standard educational settings. By using LMS for cognitive rehabilitation, it allows for the development of strategies to reinforce the importance of repetition and practice, which is in line with the overall aim of cognitive rehabilitation. Cognitive rehabilitation programs can also be tailored to each client’s needs, while still pulling upon activities to reinforce the content. LMS also have implications for clinical practice and for expanding TR. While there are some limiting aspects such as added daily time, the advantages of individualization and limiting the access to inappropriate content for the time, outweigh the shortcomings in development and implementation.

While establishing usability is imperative, utilizing the system clinically is imperative to understand its feasibility, as well as a greater scope of clinical usability. Deployment of the remote cognitive rehabilitation is essential to evaluate if the intervention works, and to what extent.

5.0 EVALUATION OF TELEREHABILITATION FOR THE DELIVERY OF COGNITIVE REHABILITATION

5.1 INTRODUCTION

For individuals with cognitive disabilities, especially TBI, generalization of clinically learned cognitive rehabilitation strategies is limited (Boman, Lindstedt, Hemmingsson, & Bartfai, 2004). Furthermore, individuals have difficulty applying strategies learned in the clinic to their home and work environments (Lee, Powell, & Esdaile, 2001; Sohlberg & Raskin, 1996). As a result, to facilitate increased generalization to everyday life, rehabilitation services should be conducted in the home and community environments where the person lives and functions daily, as much as possible (Bergquist, Boll, Corrigan, Harley, Malec, Millis, et al., 1994; Uomoto, 1992). Ideally, these natural environments are the most familiar to the client and promote generalization (Mateer, Sohlberg, & Youngman, 1990). In general, cognitive rehabilitation employs a wide range of strategies that ultimately aim to improve the person's overall functioning. Because of the wide variety of the research related variables that include a range of treatment techniques, the outcome measures, treatment format and length of treatment, and obtaining a general conclusion is difficult. As a result, researchers have begun opting to evaluate individual cognitive rehabilitation techniques (Hampstead, Sathian, Phillips, Amaraneni, Delaune, & Stringer, 2012).

Within cognitive rehabilitation, the use of computers and other devices use has increased as access to technology has improved. While the number of interventions utilizing technology continues to increase, technological interventions can vary in their application within rehabilitation. Cognitive rehabilitation can vary from computer assisted and computer aided cognitive rehabilitation to computer based cognitive remediation training, depending upon the level of dependence on the computer applications and the involvement of a rehabilitation specialist. Computer assisted interventions provide several advantages in cognitive rehabilitation because they provide the opportunity for presentation of higher level stimuli in a standardized format that may help engage clients, allow for more accurate, objective measure of client progress on activities, and has the ability to present activities to a client based upon the current level of functioning (McGuire, 1990; Tam & Man, 2004).

Individuals in rural and remote areas often have limited access to resources and to skilled professions trained to deliver specialized medical and rehabilitation services (Callas, Ricci, & Caputo, 2000). Further, access to rehabilitation services is more difficult for individuals with disabilities who live in rural locations, compared to metropolitan areas (Demiris, Shigaki, & Schopp, 2005). Barriers to rehabilitation services for rural areas include distance to facilities, limited or lack of transportation, rural poverty, and lack of rural service providers (Schopp, Johnstone, & Merrel, 2000). As a result, individuals with disabilities may not receive the appropriate level of care due to the lack of access to specialty services and to new technologies (Johnstone, Nossaman, Schopp, Holmquist, & Rupright, 2002). Research has also found the greater the distance individuals must travel to obtain services, the less likely people are to receive that service (Johnson, Weiner, & Richardson, 1998). As a result of limited access to services, as well as limited generalization when rehabilitation services are provided in a clinical setting, telerehabilitation (TR) services may serve as a way to mitigate these challenges.

Telemedicine can be defined as the use of telecommunications for the transmission of information relevant to the diagnosis and treatment of medical conditions. Additionally, telemedicine can be defined as the provision of health services or the consultation for healthcare personnel at distant sites (Maheu & Allen, n.d.). While telemedicine is related the medical field, TR is can be defined as the application of telecommunication technology for facilitating rehabilitation services (Russell, 2007) and has the capacity to provide health care services in rural areas, enlarge rehabilitation opportunities for clients by using computer-aided systems, improve quality of life, reduce medical costs, and reduce travel time (Rogante, Grigioni, Cordella, and Giacomozzi, 2010; Enger, Phillips, vora, & Wiggers, 2003; Torsney, 2003; Zheng, Black, & Harris, 2005; Park, Peng, & Zhang, 2008).

Of the remote interventions conducted with adults with cognitive disabilities, few studies were providing cognitive rehabilitation remotely. Results from Bergquist, Gehl, Mandrekar, Lepore, Hanna, Osten, et al. (2009) indicated that compensatory cognitive rehabilitation may be effectively delivered via the Internet. As a follow-up to the clinical study, Bergquist, Thompson, Gehl, and Munoz Pineda (2010) evaluated participant satisfaction with receiving cognitive rehabilitation through instant messaging or email and a control group. Both the diary control group and the remote intervention group indicated high levels of satisfaction with the treatment received. Bourgeois, Lenius, Turkstra, & Camp, (2007) conducted telephonic spaced retrieval training to impact memory problems for adults with TBI, compared to a didactic strategy instruction. Thirty eight individuals with TBI participated in the study and results indicated that individuals in the teletherapy group reported more successful completion of treatment goals, as well as strategy use, than individuals in the didactic group. However, both groups improved in self-reported memory problems. Salazar, Warden, Schwab, Spector, Braverman, Walter et al (2000) also provided telephonic interventions to participants in their home and found similar improvements to an in-hospital cognitive rehabilitation group.

The results from these studies show that telehealth technologies such as telephone and two-way messaging can aid in delivering parts of cognitive rehabilitation to clients remotely. However, the studies evaluated did not evaluate any two-way audio and video interactive communications. There is insufficient evidence to establish whether TR technologies are effective for delivering cognitive rehabilitation remotely (Committee on Cognitive Rehabilitation Therapy for Traumatic Brain Injury, 2011c). With limited evidence to support remote cognitive rehabilitation, the overall goal of this study was to evaluate the efficacy of remote cognitive rehabilitation and to establish equivalency to face-to-face (FTF) interventions.

5.1.1 Research Aims

This project included two major aims. The first specific aim for this study was to evaluate the equivalency of cognitive rehabilitation delivered FTF and remotely using TR technologies.

Hypotheses 1: Subjects in the FTF and the TR 9-week EON-MEM interventions will result in equivalent improvements in memory and self-awareness

a) The use of TR for the delivery of cognitive rehabilitation will result in equivalent improvement in memory function, compared to FTF delivery.

The second specific aim for this study was to evaluate the overall efficacy of a cognitive rehabilitation intervention delivered FTF and TR.

Hypotheses 2: The combined 9-week EON-MEM will result in significant improvements in memory and self-awareness.

a) The 9-week EON-MEM cognitive rehabilitation program will result in significant improvement in memory function.
b) The 9-week EON-MEM cognitive rehabilitation program will result in significant improvement in self-awareness, self-regulation, and participation.

Hypotheses 3: The FTF and the telerehabilitation 9-week EON-MEM will result in significant improvements in memory and self-awareness.

a) The 9-week FTF EON-MEM cognitive rehabilitation program will result in significant improvement in memory function.
b) The 9-week FTF EON-MEM cognitive rehabilitation program will result in significant improvement in self-awareness, self-regulation, and participation.
c) The 9-week TR EON-MEM cognitive rehabilitation program will result in significant improvement in memory function.
d) The 9-week TR EON-MEM cognitive rehabilitation program will result in significant improvement in self-awareness, self-regulation, and participation.

5.2 MATERIALS AND METHODS

5.2.1 Instrumentation

This study required multiple steps prior to clinical implementation. For a more detailed explanation of the development, please refer to Chapter 5.

5.2.1.1 Intervention Instrumentation

The Ecologically Oriented Neurorehabilitation of Memory (EON-MEM) is a 21-week, systematic, structured, and detailed treatment manual approach to cognitive rehabilitation designed to train clients to compensate for memory impairments. Focus is placed on everyday memory problems and practice exercises in naturalistic environments, which provide ecological validity to the program. The EON-MEM teaches clients using a four-step method for remembering information using compensatory strategies that incorporate mnemonics and written aids. This four-step method (WOPR) is Write, Organize, Picture, and Rehearse. Additionally, the EON-MEM teaches clients to use the peg system for remembering numbers. The peg system is a series of words that rhyme with numbers 0 through 12 (e.g., 0-hero, 1-bun, 2-shoe, etc.). The peg system is easy to learn and allows clients to visualize (Picture), further emphasizing the WOPR system. Finally, each week, clients are introduced to a new module and then given 7 homework assignments that must be completed one each day. The Therapist Guide does not make recommendations on minimum clinician training prior to administering the EON-MEM to clients. Each session, with script and recommended prompts, standardized for the clinician. To ensure consistency in the administration of the EON-MEM protocol, a training group was formed at the University of Pittsburgh for all researchers, and additional weekly staff meetings that focused on administration procedures were held throughout the duration of the study.

The EON-MEM was developed to be consistent with best practices in cognitive rehabilitation identified by Chestnut, Carney, Maynard, Mann, Patterson, & Helfand (1999) and by Cicerone, Dahlberg, Kalmar, Langenbahn, Malec, Bergquist et al. (2000). The EON-MEM also advocates for the use of alarms and electronic devices to aid in memory, thereby following evidence-based reviews to incorporate additional strategies and techniques in cognitive rehabilitation. The Therapist Guide also details that some individuals may not need every module in the protocol, while some many need additional time spent on a particular area, allowing for individual customization of the cognitive rehabilitation protocol. Research has found that the EON-MEM showed improvements in everyday declarative or prospective memory for people with brain injury, stroke, and other neurological conditions (Stringer, 2011). Stringer (2011) conduced the EON-MEM with 15 participants with TBI, 12 with stroke, and 6 with other neurological conditions to determine the response of memory training on different diagnoses comparing before and after intervention. Results indicated all participants showed statistically significant improvement in memory performance, regardless of severity of or etiology of memory deficits.

The EON-MEM Therapist Guide states that every client who participates in the cognitive rehabilitation protocol does not need to participate in the entire program, for various reasons. Some clients may have limitations in specific memory areas (e.g., prospective memory, remembering oral information), may be motivated to only improve areas specific to their ability to work or live independently, while others have limited funding available for cognitive rehabilitation. Some clients may benefit from a shortened EON-MEM protocol. As a result, the

EON-MEM is modifiable to meet the client's specific needs or time frame. According to the Therapist Guide, all clients need to learn the WOPR method and the peg system.

In this study, the subjects met with a researcher for nine sessions to deliver content to the subjects, which allowed for consenting, pre and post testing within a 15 week time frame. Table 10 displays the modified protocol with a breakdown of the modules presented in each week.

Table 13. Ecologically Oriented Neurorehabilitation of Memory – Modified

Week	Module	Topic
1	I: Introduction	Goal Setting (in person)
2	I: Introduction	Introduction to WOPR
3	II: Numbers	Introduction to Numbers Application
4	II: Numbers	Using WOPR to Learn Numbers
5	III: Appointments and Future Tasks	Using WOPR to Learn Appointments
6	III: Appointments and Future Tasks	Using WOPR to Remember Future Tasks
7	IV: Oral and Written Information	Organizing Information Using Acronyms and Acrostics
8	IV: Oral and Written Information	Putting it all Together; Review and Troubleshooting
9	V: Conclusion	Measuring Progress

In order to increase the intervention fidelity, researchers responsible for delivering the EON-MEM participated in training to ensure accurate and consistent administration. All researchers provided the EON-MEM intervention to clients one term prior to involvement in the research study. These training sessions with clients were taped and reviewed to provide feedback and recommendations prior to implementation of the research protocol. During the EON-MEM administration, additional weekly supervision sessions were held to discuss the previous weeks sessions and to plan for the upcoming session.

5.2.1.2 Telerehabilitation Instrumentation

Two independent TR technologies were used together to deliver cognitive rehabilitation remotely. VISYTER was to facilitate remote meetings between the researchers and the subjects, while a tablet PC with Moodle was used to complete the daily cognitive rehabilitation activities.

VISYTER

The versatile and integrated system for TR (VISYTER) was selected as the videoconferencing system and was intended to replicate FTF meetings between the clinician and the client (Parmanto, Saptono, Pramana, Pulantara, Schein, Schmeler, et al., 2010). VISYTER was developed through the Rehabilitation Engineering Research Center on TR and has been widely used in TR studies conducted at the University of Pittsburgh. According to Parmanto et al., (2010) VISYTER is a robust modality for creating TR applications due to its ability to be applied in diverse settings. The core components of VISYTER consist of an easily installable software application, a set of off-the-shelf hardware, and a secure server system. VISYTER is a unified system that provides both real-time and asynchronous communication to support the collaboration and delivery of TR. Each weekly remote cognitive rehabilitation session would be completed via VISYTER, with the researcher located at the University of Pittsburgh, Pittsburgh PA and the subjects at the Hiram G. Andrews Center, Johnstown PA.

VISYTER was designed with the highest level of security protection, making it ideal for remote cognitive rehabilitation services. VISYTER was designed to meet the industry standard security policies, including an authentication system for all users, which also controls the user's access to specific clinic venues where the remote sessions take place, and encryption of all user authentication and the communications between the sites using a symmetric encryption key

(Parmanto et al., 2010). More specifically, VISYTER's security measures include firewalls for the secure servers and all computers that can access the system; encryption of all communication sessions between the researcher and subject sides; and compliance with the Health Insurance Portability and Accountability Act of 1996 (HIPAA) requirements for protecting health-related personal information (Parmanto, et al. 2010).

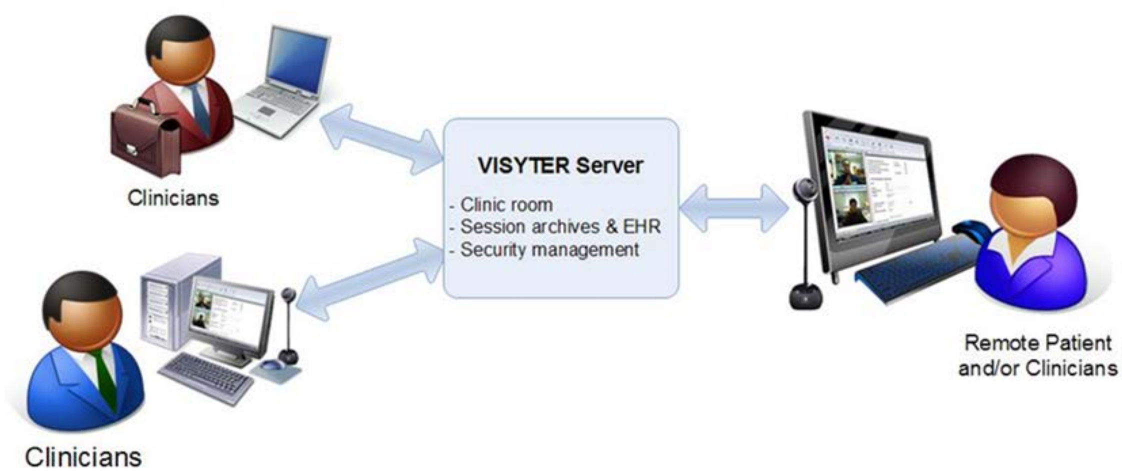

Figure 11. VISYTER

VISYTER was selected as the mechanism for videoconferencing due to its robustness, high usability, and reliability. Previous research has shown that VISYTER provides a framework for the delivery of high quality TR. VISYTER was reliably and satisfactorily used to provide remote wheelchair assessments and prescriptions in rural communities throughout Western Pennsylvania (Schein, Schmeler, Brienza, Saptono, & Parmanto, 2008; Schein, Schmeler, Holm, Pramuka, Saptono, & Brienza, 2011; Schein, Schmeler, Holm, Saptono, & Brienza, 2010). Additionally, VISYTER was used to deliver remote autism assessments from the University of Pittsburgh to the Hiram G. Andrews Center (Schutte, 2012).

Automated Delivery of Remote Cognitive Rehabilitation Materials

The second remote cognitive rehabilitation component consisted of two integrated parts, an online learning management system and a Tablet PC. As previously described in Chapter 5, Adobe® Captivate® 5 was used to author the electronic format of the EON-MEM activities. Once the activities were finalized, they were loaded into a learning management system (Moodle). Moodle is an open source learning management system accessible on an Asus Eee Pad Transformer. A total of eight tablets were purchased to be used in this clinical study. Each tablet was assigned a unique user that would use the tablet to access a unique Moodle course.

5.2.1.3 Outcome Instrumentation

Several outcomes were used for this study. Table 11 provides a breakdown of the measures used, as well as information regarding scoring and interpretation. To measure the degree of memory deficits, the Wechsler Memory Scale – IV Logical Memory and the Memory for Intentions Test were used.

The Wechsler Memory Scale – IV (WMS-IV) is a standardized measure of various memory forms and working memory abilities for individuals ages 16-90 (Wechsler, 2009). For this study, only the logical memory subtests were used. The logical memory subtests require an individual to listen to two different stories and immediately retell each story from memory. The logical memory subtests also require an individual to recall and retell the story after delay period, as well as recognition of pieces from the story. The WMS-IV is one of the oldest and most popular measures of memory and its psychometric properties have been well established. Internal consistency for Logical Memory I (LMI) and Logical Memory II (LMII) have been established at r =0.82 and =0.85, respectively. For individuals with cognitive disabilities, a high internal consistency has also been reported (0.82-0.91) with an overall *r*=0.86 for individuals with disabilities. Additionally, test-retest reliability for LMI (0.74) and LMII (0.71) and inter-scorer agreement (0.98 to 0.99) for all measures is also well established. Content and construct validity have also been established for all subtest of the WMS-IV (Wechsler, 2009)

The Memory for Intentions Test (MIsT) is a standardized measure of prospective memory that requires individuals to perform eight different prospective memory tasks over a 30-minute period. Individuals are required to engage in a distracter task, word-search puzzle, during the testing period. The MIsT generates an overall prospective memory total, as well as 2-Minute Time Delay, 15-Minute Time Delay, Time Cue, Event Cue, Verbal Response, and Action Response subscales. The MIsT also includes an eight-item multiple choice recognition posttest that generates a retrospective recognition total. Only the prospective memory total was used for this study. Raw scores are generally converted into percentiles, however, for the purpose of comparison, all raw scores were converted into *z* scores using the observed score and the normative sample mean and standard deviation. The MIsT has alternate forms to allow for pre and post intervention administration. Reliability and validity has been established for the MIsT and internal consistency was measured by coefficient alpha, and results from the six subscales that make up the PMT = 0.93. Additionally, alpha coefficients for each of the subscales ranged from 0.54-0.64. Interrater reliability (ICC ranged from 0.81-0.96), Split-half reliability (0.97), and Test-retest reliability for PMT 0.78 is adequate. Content validity and convergent validity have also been demonstrated. The Assessment of Intentional Memory, which was the precursor to the MIsT, proved to be a sensitive measure to changes in prospective memory ability as the result of treatment (Raskin & Buckheit, 1998; Raskin, 2009). The MIsT has been researched with individuals with Alzheimer's, ABI, Parkinson's, HIV, MS, Schizophrenia, Older Adults, and MCI (Raskin, 2004; Woods, Moran, Dawson, Carey, Grant, 2008; Raskin, Buckheit, Sherrod, 2010).

The Self-Awareness of Deficits Interview (SADI) is an interviewer scored structured interview which measures three levels of awareness, self-awareness of deficits, self-awareness of functional implications of deficits, and ability to set realistic goals, using a 4-point rating scale from 0 to 3, which obtains a total score of 9. Higher scores on each index of the SADI represent lower levels of awareness (Fleming Strong, & Ashton, 1996). Test-retest reliability for total SADI (ICC=0.94) and for sub-section scores (ICC=0.85-0.86) is adequate. Interrater reliability achieved a fair agreement (subscale ICC= 0.57-0.78 and total score ICC=0.82) (Fleming et al., 1996; Simmond & Fleming, 2003).

The Self-Regulation Skills Interview (SRSI) is a measure of metacognitive skills in everyday living. The SRSI consists of six items that evaluate emergent self-awareness, anticipatory self-awareness, motivation to change, strategy generation, strategy use, and strategy effectiveness. Overall scores are rated on a scale of 0-10 and reflect level of awareness, self-rating of readiness to change, and strategy behavior. Lower scores represent a higher level of skill. According to Ownsworth, McFarland, and Young (2000), the SRSI is sensitive to changes in levels of self-regulation. Interrater reliability (Standardized Alpha) has been established for each of the six items: Emergent Self-Awareness = 0.83, Anticipatory Self-Awareness = 0.81, Motivation = N/A, Strategy Generation = 0.85, Strategy Use = 0.87 and Strategy Effectiveness = 0.92. Test-retest reliability (Standardized Alpha) has been established: Emergent Self-Awareness = 0.80, Anticipatory Self-Awareness = 0.91, Motivation = 0.81, Strategy Generation = 0.69, Strategy Use = 0.80 and Strategy Effectiveness = 0.85.

For both the SRSI and the SADI, a consensus scoring was utilized. Three researchers independently rated each subject response according to the scoring guideline. Each score was then compared by the researchers. If each researcher identified the same score, that number was recorded. If a discrepancy between researcher scores occurred, each response was discussed and independently rerated until a consensus was reached.

The Participation Assessment with Recombined Tools-Objective/Satisfaction (PART-OS) is a participation measure that looks at the fit between participation and the person's values, preferences and abilities. The PART-OS consists of two parts, objective items and satisfaction or subjective items. The objective portion of the tool is a combination of the Craig Handicap Reporting Technique, the Participation Objective, Participation Subjective questionnaire, the Community Integration Questionnaire – version 2, and the Mayo-Portland Adaptability Inventory – version 2. The subjective portion of the PART-OS focuses on satisfaction was developed at Mount Sinai Medical Center after the Objective portion was completed. This portion of the tool focuses on importance of various household and community participation activities and the satisfaction people experienced from them (Mount Sinai School of Medicine Department of Rehabilitation Medicine, 2007). Higher scores reflect better levels of participation and satisfaction.

The Cognitive Symptom Checklist (CSC) was developed as a screening tool to supplement formal neuropsychological and to establish a baseline for cognitive problems and to measure post-treatment progress (O'Hara, Harrell, Bellingrath, & Lisicia, 1993). The CSC assesses five areas, attention/concentration, memory, visual processes, language, and executive functions. The CSC Memory form was used as a supplement to the standardized memory testing. The CSC Memory further evaluates difficulties with memory in the areas of activities of daily living, time, receptive language, expressive language, and personal areas such as phone numbers and anniversaries. The CSC Memory has 85 total items. For the purpose of this study, total number of problems for the subscores and a total score were calculated. Higher scores indicate more difficulty with memory.

The Everyday Memory Questionnaire (EMQ) is a subjective measure of memory difficulties experienced in everyday life (Sunderland, Harris, & Baddeley, 1983). Multiple variations of the EMQ have published and vary based upon the number of questions presented and the response scales (Sunderland, Harris, & Baddeley, 1983; Tinson & Lincoln, 1987; Baddeley, 1997). For the purpose of this study, the 28-item EMQ Revised was used with a modified 5-point Likert scale ranging from Once or less in the last month (1) to once or more in a day (5) (Sunderland, Harris & Baddeley, 1984; Baddeley, 1997; Royle & Lincoln, 2008). Overall scores range from 28 to 140, with higher scores indicating more difficulty with memory. Internal consistency testing resulted in Cronbach's alpha of 0.92 (Royle & Lincoln, 2008).

The Prospective and Retrospective Memory Questionnaire (PRMQ) is a brief, self-report measure of prospective and retrospective memory (Crawford, Smith, Maylor, Della Salla, & Logie, 2003). The PRMQ contains 16 items and asks clients to rate the frequency of their memory problems on a 5-point Likert from Very Often (5) to Never (1). The PRMQ produces three scores, including total memory which ranges from 16 to 80), as well as retrospective memory and prospective memory scales, both ranging between 8 and 40, with higher scores indicating more difficulty with memory. The PRMQ was selected in addition to the EMQ because of its evaluation of prospective memory; the PRMQ contains three questions that evaluate prospective memory. Reliability for the PRMQ was established and internal consistency for the total scale was 0.89, while the prospective memory was established as 0.84 and the retrospective memory was 0.80.

Table 14. Outcome Tools Summary

Tool Name	Domain Measured	Scores	Scores Reflect
Wechsler Memory Logical Memory I Logical Memory II Logical Memory II-Recognition	Memory	Scaled Score Scaled Score *T* Score	Higher scores indicates better memory performance
Memory for Intentions Test Prospective Memory	Prospective Memory	*T* Scores	Higher *T* Scores indicates better memory performance
Everyday Memory Questionnaire	Subjective Memory Failures	Questionnaire Score Range: 28-140)	Lower scores indicate better memory performance
Prospective and Retrospective Memory Questionnaire	Subjective Memory Failures	Questionnaire Scores Total: 16-80 Prospective: 8-40 Retrospective: 8-40	Lower raw scores indicate better memory performance
Cognitive Symptoms Checklist Memory	Subjective Memory Failures	Questionnaire Score Range: 0-85	Lower scores indicate better memory performance
Self-Awareness of Deficits Interview	Self-Awareness	Questionnaire Score Range: 0-9	Lower scores reflect better self-awareness
Self-Regulation Skills Interview Emergent Awareness Motivation to Change Strategy Behaviors	Self-Awareness	Questionnaire Scores All Range: 0-10	Lower scores reflect better self-regulation
Participation Assessment with Recombined Tools-Objective/Satisfaction Objective and Subjective	Participation	Questionnaire Score using scoring algorithm	Higher scores reflect better levels of participation and satisfaction.

5.2.2 Research Subjects

Subjects were recruited through a group cognitive rehabilitation program at the Hiram G. Andrews Center (HGAC), a state-operated vocational facility located Johnstown, PA. HGAC primarily serves consumers of Pennsylvania's Office of Vocational Rehabilitation (OVR). HGAC students are individuals age 17 and older with a disability. HGAC offers 18 unique vocational training programs, (e.g., Architectural Drafting, Commercial Cleaning, and Office Technology). There are three terms per year, spring, summer, and fall, each 16 weeks long.

Inclusion criteria consisted of the following: primary disability must be cognitive, (i.e., primary impairment was a result of cognitive disability), self-report difficulties with memory, expressed interest in improved functional status in independent living or employment, and was native English speaking. Additional inclusion criteria included: the individual did not possess a primary mental health/psychiatric disability and does not demonstrate recent psychiatric symptomology, (there must be evidence of full resolution of significant past psychiatric problems), the individual was not actively using illegal drugs or was not using alcohol in excess, and the individual expresses an understanding of and willingness to fully participate in the program

Exclusion criteria for participation included the following: if cognitive disability was a result of a TBI less than 6 months prior or they were not medically stable, major sensory impairments that may prevent the individual from using the technology (other than mild visual difficulties corrected with glasses and/or contacts), or exclusion from participation in the study included having a primary psychiatric, mental retardation, or substance abuse diagnosis.

5.2.3 Testing Protocol

This study was a quasi-experimental pre/post design. Subjects consented and were then added to the subject list for that term. Subjects were randomized into the TR intervention group (n=20) or FTF intervention group (n=18). Once subjects were randomized into a group, they were then randomly assigned a researcher who would deliver the EON-MEM intervention to that subject. After the subject was randomly assigned to the group and the researcher delivering the EON-MEM, they were then randomly assigned a testing administrator. Testing was conducted by a researcher, who was not the memory researcher, and was conducted only after the subject consented and prior to the first meeting with the EON-MEM researcher. Testing was completed FTF for both groups. Once all subjects finished baseline testing, they were informed which group they were assigned to. Institutional review board approval was obtained through the University of Pittsburgh, prior to any data collection. Figure 12 displays a flowchart for the clinical trial procedures.

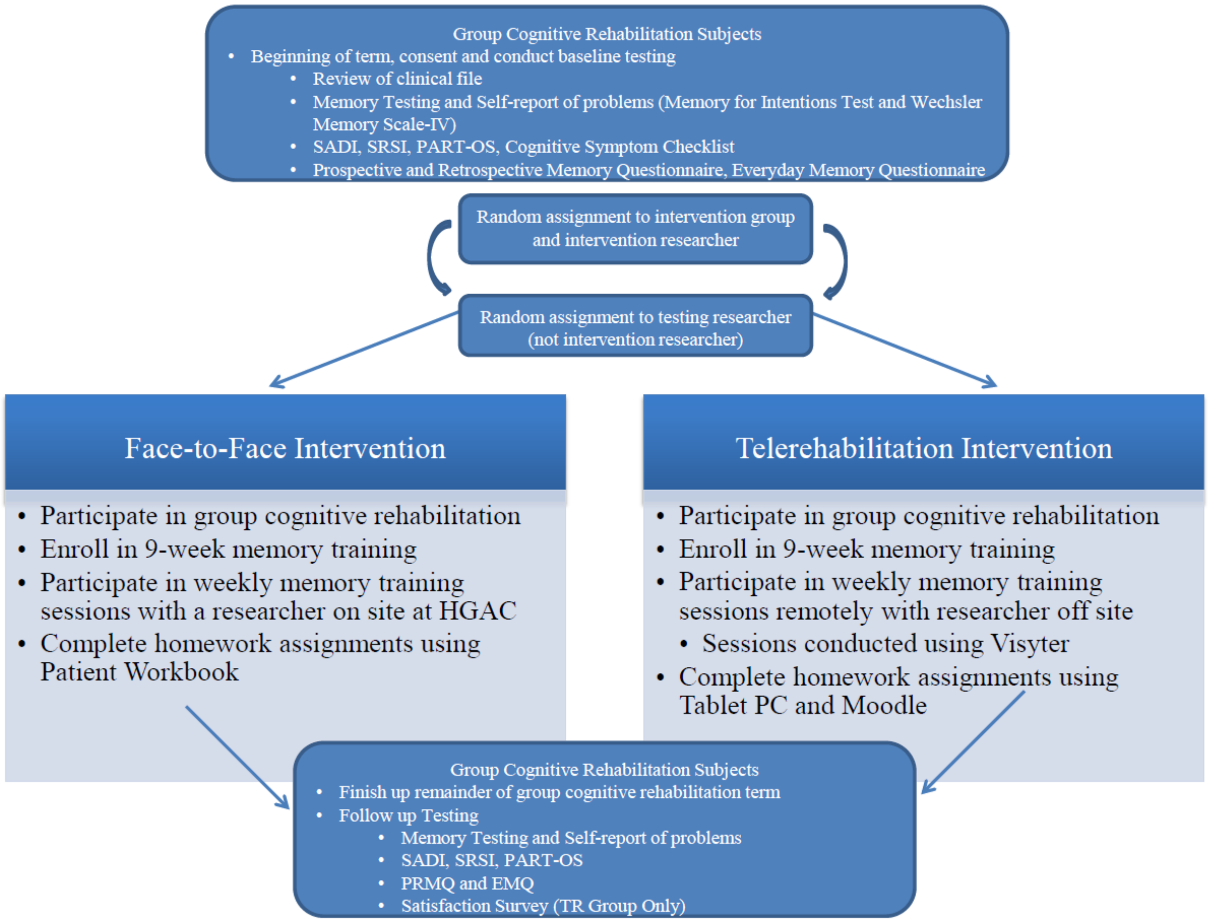

Figure 12. Clinical Trial Flowchart

5.2.3.1 Face-to-Face

Subjects in the FTF group participated in a group cognitive rehabilitation program, with all the same program components, plus an individual 9-week memory training program with a memory rehabilitation specialist (Researcher). The FTF group met in person weekly, and used a paper and pencil based homework. Each week, subjects in the FTF group met individually with the researcher in the research office, a quiet, private space that has a computer station and a working space. All individual sessions were recorded using VISYTER so the sessions could be reviewed by the research team to ensure consistency in administration. The FTF memory researcher initiated the weekly memory sessions by accessing the VISYTER portal to begin the recording. When the weekly session was completed, the entire session was archived by the secure portal. At the end of each weekly session, the researcher gave the subject 5 homework assignments to complete, one each week day until the next session.

Session 1 consisted of an initial meeting with the memory researcher and provided structure for what was to be expected with the memory training and consisted of training on what to do with the homework book. The workbook was distributed to the clients and joint goals set. Subjects were instructed to sign out their notebook from a researcher when they were ready to complete their homework.

Sessions 2-8 consisted of sessions that deliver the memory intervention content. These sessions consisted of a weekly meeting with the same memory researcher and were held on the same day of the week, every week for the duration of the memory intervention. The weekly meeting consisted of the same parts, every time. An introduction for the session material that day, answer any questions the client may have, check homework from the previous week, introduce the new topic, verify understanding, assign homework for the next week.

In between sessions, subjects were responsible for the five homework assignments, one to be done every weekday until the next therapy session. During the next session, the researchers verified that the subjects had completed the homework and done so accurately. If the subject had not successfully completed the homework assignment, the researcher would repeat the material from the previous week.

Session 9 consisted of a wrap up meeting to discuss any final challenges with the memory intervention. Each individual weekly session lasted between approximately 30 and 90 minutes. Daily homework activities took approximately 30-45 minutes to complete.

Figure 13. Face-to-Face Meeting with Workbooks

5.2.3.2 Telerehabilitation Group

Subjects in the TR intervention group participated in a group cognitive rehabilitation program, with all the same program components, plus an individual 9-week memory training program with the researchers. The TR intervention consisted of two levels of TR technology, VISYTER to replicate the FTF meetings and Moodle and the Tablet PC to complete the daily homework activities. For the remote weekly meetings, the TR group subjects met via VISYTER, with the memory clinician (Researcher) at the University of Pittsburgh, or in a TR office in a different part of the Hiram G. Andrews Center, and the subject in a specific TR office located near the group cognitive rehabilitation office. The two computer stations were connected by a broadband internet connection. All individual sessions were recorded using VISYTER so the sessions could be reviewed by the research team to ensure consistency in administration.

The subjects were also provided a Wi-Fi enabled Asus tablet, equipped with a link to the University of Pittsburgh's Moodle, to complete their daily homework exercises. Moodle served as a way to automate the homework activities for the subject. The subjects were instructed to bring their tablets with them to each remote session in order to use the notepad feature on the tablet to mimic writing notes with a pencil and paper. The researcher also had access to the subject's Moodle site so they could track homework progress and unlock the homework activity the subject should be completing. Prior to each session, the researcher would log into Moodle and access that specific subject's homework log to ensure the client completed an appropriate number of homework activities and that the homework was completed accurately. Figure 14 displays a remote cognitive rehabilitation meeting, with a homework log in Moodle opened as the researcher was checking accuracy.

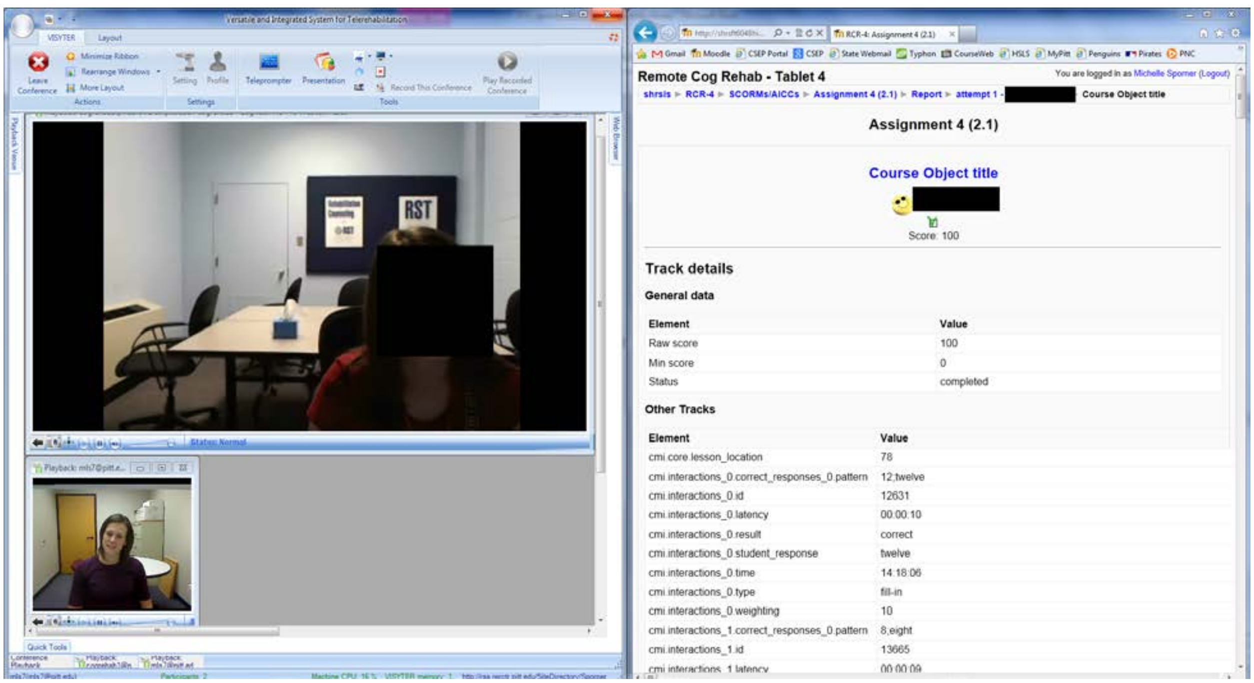

Figure 14. Side-by-Side Desktop View of VISYTER Session and Moodle Review

Session 1 consisted of an initial meeting with the memory researcher and provided structure for what was to be expected with the memory training. This session was conducted in person to establish a rapport with the subject. Each subject was trained on using the tablet to access the necessary features and to ensure they understood how to access the Moodle site to complete their homework. The tablet was distributed to the subjects and joint goals set. The subjects were also introduced to the VISYTER system. During this session, the researcher also detailed the guidelines for how the subject participated in the weekly, live sessions with the researcher. These guidelines include using the tablet in a quiet space, not allowing others to use the tablet and returning it to the researchers when they are finished completing their homework. Subjects were instructed to sign out their tablet from a researcher when they were ready to complete their homework assignment.

Sessions 2-8 consisted of weekly sessions that delivered the memory intervention content and were conducted using VISYTER. After each session, the subject logged into their portal account and began the training module for that week. An onsite researcher set up the VISYTER system for the subject to reach the remote researcher. The remote researcher administered the weekly memory protocol session, just as with the FTF sessions. Each assignment was instructed to be completed on a separate day. The assignments were "locked" to prevent the subject from doing all of the assignments in one day. Each session had five homework assignments that must be completed prior to the initiation of the next session. Moodle allowed for monitoring of the completion of homework assignments. If a subject did not complete homework assignments by 2 days after the session, a notice was sent to the onsite researchers to prompt the subject to complete the missed assignments. This helped to ensure subjects had their homework completed so the next session could be initiated in a timely manner.

Session 9 consisted of a wrap up meeting, also conducted using VISYTER, to discuss any final challenges with the memory intervention. Each individual weekly session lasted between approximately 40 and 90 minutes. Daily homework took approximately 30-45 minutes to complete.

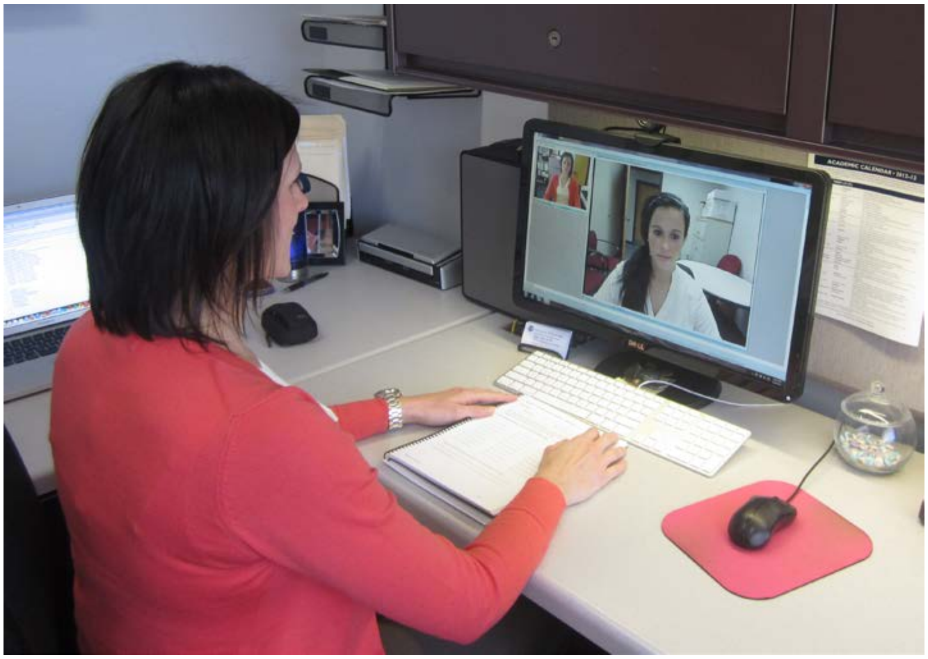

Figure 15. Remote Set-up, Subject Side

Figure 16. Remote Set-up, Subject Side

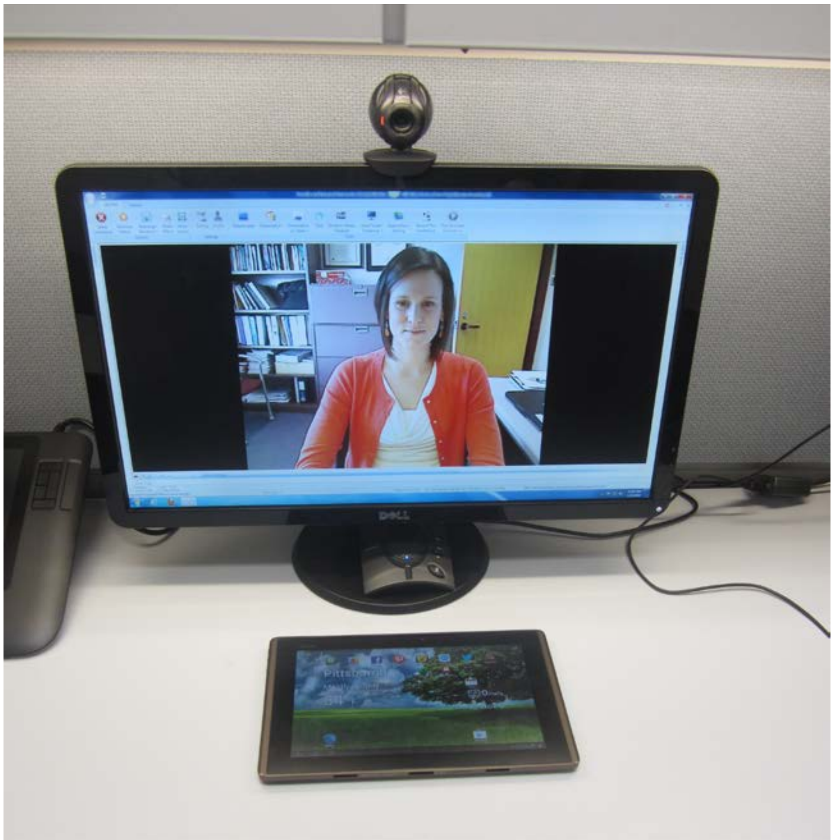

Figure 17. Remote Set-up, Researcher View

After both groups completed the protocol, follow up testing was completed. In addition to the baseline outcome tools, subjects in the TR group completed a usability questionnaire to obtain feedback on their experience using TR.

5.2.4 Data Analysis

SPSS version 21 was used for all analyses. All statistical analyses were preceded by detailed descriptive analyses of the subject characteristics, including age, sex, primary diagnosis, and IQ, using standard descriptive summaries (e.g., means, standard deviation, percentiles, ranges) and graphical techniques (e.g., histograms, scatter plots). All data was examined for normality and missing data.

5.2.4.1 Equivalency

To evaluate the first specific aim that subjects in the FTF and the remote 9-week EON-MEM interventions will result in equivalent improvements in memory and self-awareness, confidence intervals were used. The confidence interval (CI) between interventions judged to be clinically relevant and considered equivalent was ±1 for scaled scores, meaning that the TR group had to score less than the +1.0 and greater than -1.0 when compared to the FTF group. Similarly, the CI between interventions deemed to be clinically relevant and equivalent was ±3.3 for T scores, meaning the TR group had to score less than +3.3 and greater than -3.3 when compared to the FTF group. To examine the equivalence difference between the post memory items for the FTF and TR groups, the following hypothesis was calculated. A CI was calculated to estimate the range of values in which the posttest intervention differences between the FTF and TR groups were likely to lie. The CI was used to provide the basis for drawing study conclusions.

$$H_O: \mu_{TR} - \mu_{FTF} \leq -\delta \; OR \; \mu_{TR} - \mu_{FTF} \geq +\delta$$

$$H_1: \mu_{TR} - \mu_{FTF} > -\delta \; OR \; \mu_{TR} - \mu_{FTF} < +\delta$$

5.2.4.2 Efficacy and Clinical Change

Within group comparisons of pre and post data points were performed for both FTF and TR group. Depending upon data normality, either paired t-tests or Wilcoxon Signed Ranks Tests were completed. The purpose of this study was to test if both interventions worked, as opposed to testing for differences between interventions; therefore no between subject statistical analyses were conducted for the post time point. Between subject analyses were only conducted on change scores to determine if there was any significant difference in the degree of change between the FTF and TR group after completing the intervention.

To test the comparison of the average memory scores for the TR and FTF groups, both should have similar distributions. A value difference of approximately 1/3 standard deviation of the pre to post memory scores was determined as a clinically significant change. Typically, in equivalence studies, a margin or delta (δ) is chosen using clinical judgment, with reference to relevant guidance such as previous research and clinical expertise. A margin should be chosen such that a difference in interventions of such a magnitude would be considered clinically irrelevant, and anything greater would be unacceptably large.

There is variability in the overall change after cognitive interventions, coupled with the fact that memory has also been found to be a relatively stable cognitive domain. Nydén, Billstedt, Hjelmquist, & Gillberger (2001) found that in children with ADHD, Asperger's, and Reading and Writing Disorders, measures of intelligence remained stable over a two year period. Similarly, for individuals with TBI, Millis, Rosenthal, Novack, Sherer, Nick, Kreutzer, et al. (2001) found that almost 63% of individuals remained unchanged from one year to five years post TBI on standardized testing measures. Quemada, Céspedes, Ezkerra, Ballesteros, Ibarra, & Urruticoechea (2003) found modest improvements in the California Verbal Learning Test after a 6 month memory rehabilitation program. Even after intervention, a large change in memory function as measured by neuropsychological testing is not expected.

For this study, relevant guidance was obtained from previous literature evaluating the degree of change after receiving memory interventions. Evidence supporting differences between pre and post measures on memory outcome tools is varied, with relative percentage change ranging between approximately 10-80%. After review of the literature with similar interventions that presented significant changes in similar memory outcomes, the statistically significant changes ranged from 15-20% change, or roughly 1/3 standard deviation change (Thickypenny-Davis & Barker-Collo; 2007; Kaschel, Della Salla, Cantagallo, Fahlbock, Laaksonen, & Kazen, 2002; Quemada, et al., 2003; Raskin & Sohlberg, 2009). As a result, the mean difference between baseline and post scores for both intervention groups was judged to be clinically significant at 1 scaled score (WMS-IV – Logical Memory I and Logical Memory II) and 3.3 *T* scores (WMS-IV – LMII Recognition and MIsT Prospective Memory Total). Clinical change was not calculated for self-report outcome measures due to the lack of standardization in administration and variations in scoring techniques.

5.3 RESULTS

A total of 38 individuals consented to participate in this study, with 30 subjects completing the study. Figure 18 displays the recruitment and intervention stages, with number of subjects in each stage. The mean age of all subjects successfully completing the study was 20.46±1.71 years with a range from 18-25. Seventy percent of the study population was male and 30% were female, with 80% of the study population being Caucasian. Within the files of the consented subjects, many had multiple cognitive disabilities identified. The primary disabilities identified by a cognitive rehabilitation team included 7% TBI, 10% ADHD, 23% learning disorders, and 57% autism spectrum disorders (including Asperger's, pervasive developmental disability, and autism), with 3% having a diagnosis of other cognitive disorder. Most subjects had one (30%) or two (53%) cognitive diagnoses, while 17% of the subjects had three diagnoses identified in their records. The most common co-occurring diagnoses included an autism spectrum disorder or Learning Disorder diagnosis with ADHD. Almost one half of the subjects had a diagnosis of ADHD listed in their file (47%) with these numbers equally split between the FTF (7) and TR (7) groups.

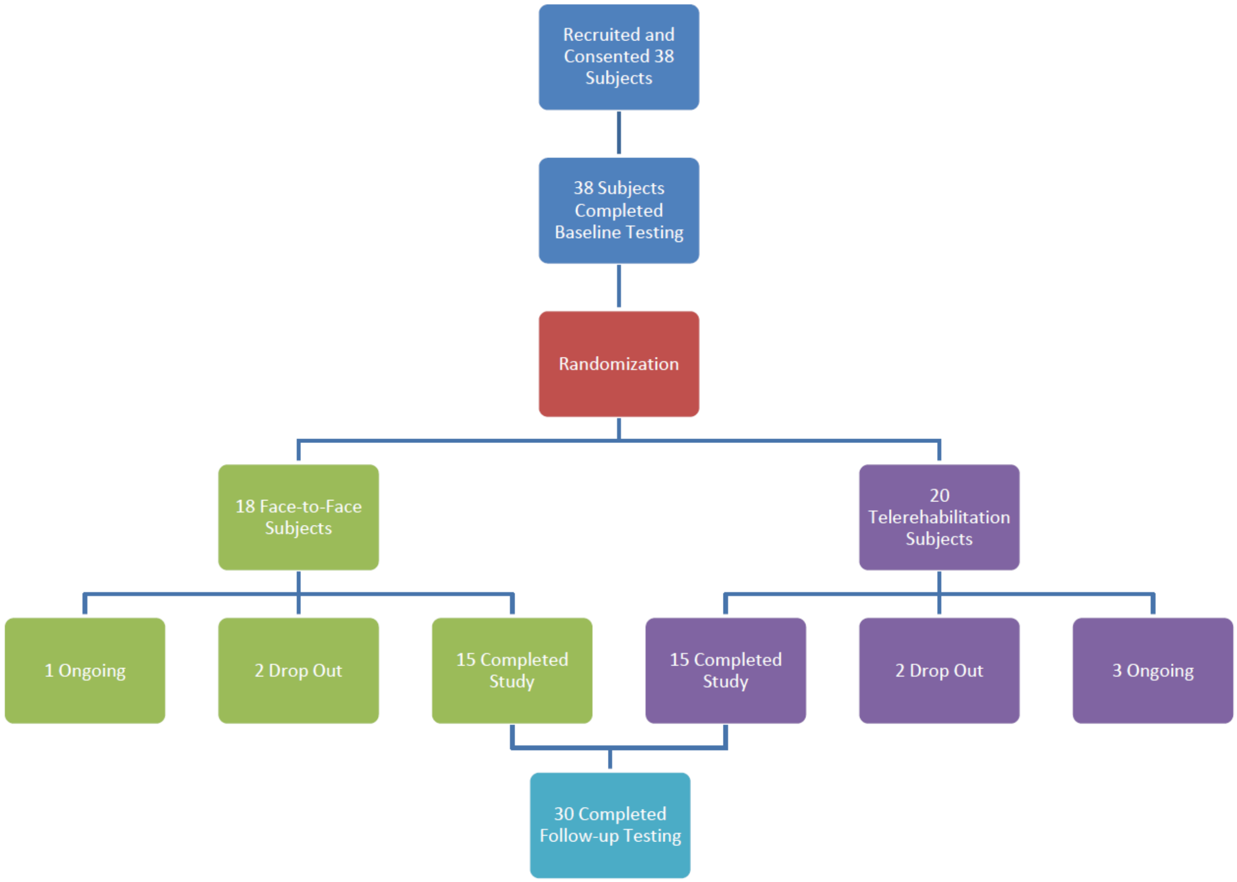

Figure 18. Clinical Trial Study Procedures

Eight subjects did not complete the clinical trial; four subjects were considered drop outs and four subjects were still enrolled in the clinical study. The reasons for drop outs included one subject choosing to discontinue participation and three subjects being discharged from the group cognitive rehabilitation program. Subjects who did not complete the intervention were not significantly different on any demographic variable, compared to subjects who did complete the study. Table 15 displays a breakdown of demographic variables collected for the 30 subjects who completed the memory intervention.

Table 15. Baseline Demographics

Measure	Group (n=30)	FTF (n=15)	TR (n=15)	P value
Age	20.46 (1.71)	20.81 (1.79)	20.11 (1.61)	0.202
Gender				
Male	70.00 (21)	80.00 (12)	60.00 (9)	0.213
Female	30.00 (9)	20.00 (3)	40.00 (6)	
Race				
African American	13.33 (4)	6.67 (1)	20.00 (3)	
Caucasian	80.00 (24)	93.33 (14)	66.67 (10)	NA
Hispanic	6.67 (2)	0.00 (0)	13.33 (2)	
Primary Disability				
Learning Disorder	23.33 (7)	20.00 (3)	26.67 (4)	
ADHD	10.00 (3)	0.00 (0)	20.00 (3)	NA
TBI	6.67 (2)	6.67 (1)	6.67 (1)	
Autism Spectrum	56.67 (17)	73.33 (11)	40.00 (6)	
Other	3.33 (1)	0.00 (0)	6.67 (1)	
Number Diagnoses				
One	30.00 (9)	26.67 (4)	33.33 (5)	NA
Two	53.33 (16)	53.33 (8)	53.33 (8)	
Three	16.67 (5)	20.00 (3)	13.33 (2)	
IQ				
FS[1]	83.45 (10.40)	86.20 (9.29)	80.50 (11.04)	0.143
Verbal	89.10 (11.23)	90.73 (9.18)	87.47 (13.09)	0.435
Performance[1]	87.83 (16.73)	92.73 (17.23)	82.57 (15.03)	0.103
Working Memory[2]	83.50 (10.87)	85.77 (11.31)	81.23 (10.36)	0.297
Processing Speed[3]	78.12 (6.66)	77.92 (6.57)	78.31 (7.00)	0.887
Similarities[4]	8.27 (2.53)	9.33 (2.19)	7.00 (2.40)	0.027
Digit Span[5]	7.00 (1.41)	6.64 (1.12)	7.57 (1.72)	0.179
Arithmetic[5]	6.89 (1.91)	7.36 (2.01)	6.14 (1.57)	0.194

Key: 1: n=29; 2: n=26; 3: n=25; 4: n=22; 5=18

There were no significant differences between the FTF and TR groups in any demographic variable, with the exception of similarities scores (p=0.027), as measured by the neuropsychological testing in the subject files. Due to the small cell sizes in race, primary disability, and number of diagnoses, comparison statistics could not be computed. The FTF group had more individuals with an ASD diagnosis than the TR group (73% vs. 40), and the TR group had more individuals with ADHD than the FTF group (20% vs. 0%). Additionally, there were no significant differences in subject demographics between the three researchers delivering the cognitive rehabilitation intervention. Table 16 displays a breakdown of the subject demographics between the three researchers delivering the cognitive rehabilitation protocol.

Table 16. Demographic Characteristics by Researcher

Measure	Researcher 1 (n=10)	Researcher 2 (n=10)	Researcher 3 (n=10)
Tested	26.67 (8)	36.67 (11)	36.67 (11)
Group			
FTF	50.00 (5)	60.00 (6)	40.00 (4)
TR	50.00 (5)	40.00 (4)	60.00 (6)
Age	19.99 (1.35)	20.57 (2.28)	20.82 (1.42)
Gender			
Male	60.00 (6)	80.00 (8)	70.00 (7)
Female	10.00 (4)	20.00 (2)	30.00 (3)
Race			
African American	20.00 (2)	10.00 (1)	10.00 (1)
Caucasian	60.00 (6)	90.00 (9)	90.00 (9)
Hispanic	20.00 (2)	0.00 (0)	0.00 (0)
Primary Disability			
Learning Disorder	40.00 (4)	20.00 (2)	10.00 (1)
ADHD	0.00 (0)	20.00 (2)	10.00 (1)
TBI	10.00 (1)	10.00 (1)	0.00 (0)
Autism Spectrum	50.00 (5)	40.00 (4)	80.00 (8)
Other	0.00 (0)	10.00 (1)	0.00 (0)
Number Diagnoses			
One	40.00 (4)	10.00 (1)	40.00 (4)
Two	50.00 (5)	70.00 (7)	40.00 (4)
Three	10.00 (1)	20.00 (2)	20.00 (2)

Table 16. (continued)

Measure	Researcher 1 (n=10)	Researcher 2 (n=10)	Researcher 3 (n=10)
IQ			
FS[1]	84.10 (7.19)	88.00 (11.05)	78.70 (11.40)
Verbal[1]	86.00 (9.68)	94.70 (9.33)	86.60 (13.16)
Performance[2]	93.80 (11.35)	86.22 (17.77)	83.30 (19.92)
Working Memory[3]	84.50 (16.13)	86.38 (6.09)	80.40 (8.85)
Processing Speed[4]	80.62 (5.34)	77.43 (8.81)	76.60 (5.99)
Similarities[5]	9.00 (3.16)	8.22 (1.56)	7.00 (1.83)
Digit Span[6]	6.80 (1.30)	7.17 (1.17)	7.00 (2.00)
Arithmetic[6]	6.00 (2.00)	7.83 (1.83)	6.71 (1.80)

1: n=35; 2: n=34; 3: n=32; 4: n=30; 5: n=28; 6: n=23

Prior to participation in the 9-week cognitive rehabilitation program, baseline testing was completed by all subjects. There were no significant differences between the FTF and TR groups on any baseline outcome measure. Table 17 displays the baseline means for the overall study group, as well as means and standard deviations for the FTF and TR groups.

Table 17. Mean Baseline Outcomes

Measure	Group (n=30)	FTF (n=15)	TR (n=15)	t	P value
WMS-IV – LMI	7.17 (3.33)	7.73 (3.33)	6.60 (3.36)	0.929	0.361
WMS-IV – LMII	6.40 (3.36)	6.67 (3.34)	6.13 (3.74)	0.429	0.671
WMS-IV – LMII Recognition	41.74 (9.73)	43.15 (10.89)	40.33 (8.55)	0.790	0.436
MIsT Prospective Memory Total[1]	35.60 (14.24)	35.69 (14.70)	35.51 (14.31)	0.034	0.973
PRMQ – Prospective[2]	19.78 (5.14)	19.20 (3.83)	20.50 (7.05)	0.332	0.755
PRMQ – Retrospective[2]	19.44 (3.84)	17.60 (1.14)	21.75 (4.99)	1.629	0.195
PRMQ – Total[2]	39.22 (8.39)	36.80 (4.32)	42.25 (11.87)	0.873	0.436
EMQ[2]	64.56 (21.54)	61.00 (15.60)	69.00 (29.41)	0.528	0.556
CSC ADL	8.33 (5.24)	7.87 (4.67)	8.80 (5.88)	0.481	0.634
CSC Time	1.40 (1.35)	1.47 (1.41)	1.33 (1.35)	0.265	0.793
CSC Receptive	3.07 (2.26)	3.27 (2.25)	2.87 (2.33)	0.479	0.636
CSC Expressive	3.37 (2.01)	3.33 (1.99)	3.40 (2.10)	0.089	0.929
CSC Personal Areas	2.53 (2.11)	2.67 (2.13)	2.40 (2.16)	0.340	0.736
CSC Total	18.70 (9.72)	18.60 (8.97)	18.80 (10.74)	0.055	0.956
PART-Objective	1.53 (0.56)	1.46 (0.65)	1.60 (0.47)	0.714	0.481
PART-Subjective	7.07 (1.68)	7.04 (1.59)	7.10 (1.83)	0.097	0.923
PART-Weighted Subj.	11.31 (4.01)	11.05 (4.17)	11.57 (3.96)	0.349	0.730

Table 17. (continued)

Measure	Group (n=30)	FTF (n=15)	TR (n=15)	t	P value
SRSI – Awareness	8.13 (0.94)	8.27 (0.96)	8.00 (0.93)	0.774	0.445
SRSI – Readiness to Change	7.43 (1.74)	7.60 (1.68)	7.27 (1.83)	0.519	0.608
SRSI – Strategy Behavior	7.66 (1.46)	7.53 (1.54)	7.78 (1.41)	0.453	0.654
SADI	7.00 (1.93)	7.13 (1.85)	6.87 (2.07)	0.373	0.712

Key: 1. n=33; 2. n=9

After completing the 9-week cognitive rehabilitation group, mean outcome scores were calculated for the FTF and TR groups. Overall, the FTF group generally had better outcome scores and fewer memory symptoms, however comparisons between groups were not run due to the scope and design of this study. Table 18 displays the follow up testing means for the overall group, as well as means and standard deviations for the FTF and TR groups.

Table 18. Mean Follow-up Outcomes

Measure	Group (n=30)	FTF (n=15)	TR (n=15)
WMS-IV – LMI	8.90 (3.93)	9.64 (3.65)	8.20 (4.18)
WMS-IV – LMII	8.07 (3.49)	8.29 (2.95)	7.87 (4.03)
WMS-IV – LMII Recognition	44.91 (10.01)	45.37 (10.40)	44.49 (10.15)
MIsT Prospective Memory Total[1]	43.75 (11.30)	45.90 (10.87)	41.88 (11.71)
PRMQ – Prospective[2]	21.56 (6.21)	20.80 (3.19)	22.50 (9.33)
PRMQ – Retrospective[2]	16.78 (6.02)	15.80 (4.27)	18.00 (8.29)
PRMQ – Total[2]	41.44 (12.63)	39.40 (7.73)	44.00 (18.17)
EMQ	48.00 (12.10)	45.80 (10.62)	50.75 (14.91)
CSC ADL	6.90 (4.59)	6.33 (5.38)	7.47 (3.74)
CSC Time	1.03 (1.19)	0.93 (0.96)	1.13 (1.41)
CSC Receptive	2.73 (2.48)	2.20 (1.91)	3.40 (2.10)
CSC Expressive	2.87 (2.05)	2.33 (1.91)	3.40 (2.10)
CSC Personal Areas	2.30 (1.76)	2.53 (1.60)	2.07 (1.94)
CSC Total	15.83 (9.59)	14.33 (8.76)	17.33 (10.43)
PART-Objective	1.58 (0.38)	1.48 (0.23)	1.68 (0.46)
PART-Subjective	7.10 (1.48)	7.27 (1.21)	6.94 (1.73)
PART-Weighted Subj.	12.12 (3.55)	11.91 (3.11)	12.31 (4.01)

Table 18. (continued)

Measure	Group (n=30)	FTF (n=15)	TR (n=15)
SRSI – Awareness	7.31 (1.29)	7.36 (1.63)	7.27 (0.92)
SRSI – Readiness to Change	7.62 (2.16)	7.36 (2.24)	7.87 (2.13)
SRSI – Strategy Behavior	5.54 (2.27)	4.95 (2.47)	6.09 (1.99)
SADI	5.86 (1.87)	5.86 (1.70)	5.87 (2.07)

Key: 1. n=33; 2. n=9

5.3.1 Equivalency

To determine if the FTF and the TR interventions resulted in equivalent changes, posttest mean differences and confidence intervals were calculated. While not significantly different, results indicate that WMS – Logical Memory I (-1.44) and MIsT Prospective Memory Total (-4.02) were outside of the predetermined cutoff ranges of -1 to +1 and -3.3 to +3.3, respectively. However, posttest mean differences for WMS – Logical Memory II (-0.42) and WMS – Logical Memory II Recognition (-0.88) both fell within the cutoff ranges of -1 to +1 and -3.3 to +3.3, respectively. Additionally, all measured posttest means fell within the standard CI range from negative to positive on each measure. Table 19 displays the posttest mean differences and confidence interval ranges for the four standardized outcome measures.

Table 19. Posttest Mean Differences between TR and FTF Groups: Testing Equivalency with Confidence Intervals

Item	TR (se) n=15	FTF (se) n=13[1]	Mean Differences (TR-FTF)	95% CI		P value
				Lower	Upper	
WMS-IV – LMI	8.20 (1.08)	9.64 (0.98)	-1.44	-1.556	4.442	0.332
WMS-IV – LMII	7.87 (1.04)	8.29 (0.79)	-0.42	-2.289	3.127	0.753
WMS-IV – LMII Recognition[1]	44.49 (2.62)	45.37 (2.78)	-0.88	-6.643	8.713	0.818
MIsT Prospective Memory Total[2]	41.88 (3.02)	45.90 (3.01)	-4.02	-4.798	12.848	0.357

1. Missing 2 subjects

The number of sessions needed to complete the 9-week EON-MEM was approximately 9 (56.7%) or 10 (26.7%) sessions, with an overall average of 9.53±0.74 sessions for the FTF group and 9.67±0.82 for the TR group. All subjects completed the 9-week EON-MEM between 9-11 sessions. Overall, 37% of all the subjects did not complete enough homework to move on at some point during the course of the memory training, or understanding of the previous week's content could not be verified. More specifically, 27% of the FTF group repeated a session, while 47% of the TR group repeated a session during the course of the 9-week EON-MEM. Additionally, the FTF group completed an average of 32 homework activities, while the TR group finished approximately 29 homework activities of the 35 possible activities.

5.3.2 Efficacy of the 9-week EON-MEM Intervention

To determine the outcome of the 9-week EON-MEM intervention, depending upon data normality, paired t-tests or Wilcoxon signed-ranked tests were calculated for all subjects, as well as each group individually to determine statistical significance after intervention. In addition to statistically significant changes, the clinical significance of the intervention was also evaluated using change scores.

5.3.2.1 Combined Intervention Group

Memory function, as measured by standardized objective outcomes, for subjects after 9-week EON-MEM resulted in statistically significant improvements in WMS – Logical Memory I (p=0.001), WMS – Logical Memory II (p=0.001), and MIsT Prospective Memory Total (p=0.001). Although improvements were observed in WMS – Logical Memory II Recognition, changes were not significantly different after the intervention (p=0.055). Self-awareness of memory deficits (p=0.001) and strategy behaviors (0.002), as measured by the SRSI, also significantly improved after completing the 9-week EON-MEM program. Subjects also significantly improved in self-awareness (p=0.002). Results also indicate subjective memory difficulties in everyday life also significantly decreased (EMQ; p=0.044). Although not significantly different, the number or the frequency of memory difficulties measured by the cognitive symptoms checklist also decreased after completion of the intervention (range p=0.072 to p=0.530). While memory difficulties measured by the EMQ significantly decreased, and although not significantly different pre to post, results from the PRMQ indicate a slight increase in prospective memory problems (p=0.060), while retrospective (0.104) and total memory problems (0.317) also slightly decreased. Table 20 presents the objective outcome measures, while Table 21 displays the subjective outcome measures.

Table 20. Combined Intervention Group Objective Outcomes Measured at Baseline and Follow-up

Outcome Measure	Time	Combined Intervention Group (n=30)	p-value
WMS-IV – LMI	Pre	7.10 (3.37)	0.001
	Post	8.90 (3.93)	
WMS-IV – LMII	Pre	6.35 (3.40)	<0.000
	Post	8.07 (3.49)	
WMS-IV – LMII Recognition	Pre	41.84 (9.89)	0.055
	Post	44.91 (10.09)	
MIsT Prospective Memory Total	Pre	36.80 (12.92)	0.001
	Post	43.75 (11.30)	

Table 21. Combined Intervention Group Self-Report Outcomes Measured at Baseline and Follow-up

Outcome Measure	Time	Combined Intervention Group (n=30)	p-value
EMQ[1]	Pre	64.56 (21.54)	0.044
	Post	48.00 (12.10)	
PRMQ Prospective	Pre	19.78 (5.14)	0.060
	Post	21.56 (6.21	
PRMQ Retrospective	Pre	19.44 (3.84)	0.104
	Post	16.78 (6.02)	
PRMQ Total	Pre	39.22 (8.39)	0.317
	Post	41.44 (12.63)	
CSC ADL	Pre	8.33 (5.24)	0.128
	Post	6.90 (4.59)	
CSC Time	Pre	1.40 (1.35)	0.172
	Post	1.03 (1.19)	
CSC Receptive	Pre	3.07 (2.26)	0.349
	Post	2.73 (2.48)	
CSC Expressive	Pre	3.37 (2.01)	0.087
	Post	2.87 (2.05)	
CSC Personal Areas	Pre	2.53 (2.11)	0.530
	Post	2.30 (1.76)	
CSC Total	Pre	18.70 (9.72)	0.072
	Post	15.83 (9.59)	
SRSI – SA	Pre	8.09 (0.92)	0.003
	Post	7.31 (1.29)	
SRSI – RC*	Pre	7.41 (1.76)	0.623
	Post	7.62 (2.16)	
SRSI – SB	Pre	7.66 (1.48)	0.000
	Post	5.54 (2.27)	
SADI	Pre	6.93 (1.93)	0.002
	Post	5.86 (1.87)	
PART – O	Pre	1.54 (0.57)	0.068
	Post	1.58 (0.38)	
PART – S	Pre	7.08 (1.71)	0.767
	Post	7.10 (1.48)	
PART – WS	Pre	11.30 (4.08)	0.060
	Post	12.12 (3.55)	

Key: 1. For EMQ and PRMQ, n=9 total; *This measure should not change pre-post

5.3.2.2 Face-to-Face and Telerehabilitation Intervention Groups

Analyses of changes in the FTF and TR groups were also completed individually. Overall, 67% of the subjects in the FTF group reported memory improvements, while 20% stated they did not believe their memory got better and 13% were unsure. With respect to the TR group, 100% reported believing their memory had improved after participating in the 9-week memory training intervention.

Participation in either the FTF or TR 9-week EON-MEM resulted in significant improvements in WMS – Logical Memory I (FTF p=0.038, TR p=0.002) and WMS – Logical Memory II (FTF p=0.017, TR p=0.001). Individuals in the FTF group also significantly improved in prospective memory performance on the MIstT Prospective Memory (p=0.003). Although not significantly different, participation in the TR group improved prospective memory performance on the MIstT Prospective Memory (p=0.109). Neither the FTF or TR group significantly improved on the WMS – Logical Memory II (FTF p=0.415, TR p=0.070). Both the FTF and TR groups significantly impacted strategy behaviors (FTF p<0.000, TR p<0.000) on the SRSI, as well as self-awareness of their disability as measured by the SADI (FTF p=0.026, TR p=0.002). Participation in the TR group significantly improved self-awareness of memory deficits (TR p=0.016), while participation in the FTF group did not result in significant changes of self-awareness of memory deficits (FTF p=0.057). Table 22 displays the pre to post objective outcome measures, while Table 23 reports the self-report measures of memory, self-awareness, and participation.

Table 22. FTF and TR Group Objective Outcomes Measured at Baseline and Follow-up

Outcome Measure	Time	FTF	P	TR	P
WMS-IV – LMI	Pre	7.64 (3.43)	0.038	6.60 (3.36)	0.002
	Post	9.64 (3.65)		8.20 (4.18)	
WMS-IV – LMII	Pre	6.57 (3.13)	0.017	6.13 (3.74)	0.001
	Post	8.29 (2.95)		7.87 (4.03)	
WMS-IV – LMII Recognition	Pre	43.47 (11.23)	0.415	40.33 (8.55)	0.070
	Post	45.37 (10.40)		44.49 (10.15)	
MIsT Prospective Memory Total	Pre	38.29 (11.48)	0.003	35.51 (14.31)	0.109
	Post	45.90 (10.87)		41.88 (11.71)	

Table 23. FTF and TR Group Self-Report Outcomes Measured at Baseline and Follow-up

Outcome Measure	Time	FTF (n=15)	P	TR (n=15)	P
EMQ	Pre	61.00 (15.60)	0.042	69.00 (29.41)	0.197
	Post	45.80 (10.62)		50.75 (14.91)	
PRMQ Prospective	Pre	19.20 (3.83)	0.195	20.50 (7.05)	0.267
	Post	20.80 (3.19)		22.50 (9.33)	
PRMQ Retrospective	Pre	17.60 (1.14)	0.441	21.75 (4.99)	0.177
	Post	15.80 (4.27)		18.00 (8.29)	
PRMQ Total	Pre	36.80 (4.32)	0.392	42.25 (11.87)	0.667
	Post	39.40 (7.73)		44.00 (18.17)	
CSC ADL	Pre	7.87 (4.67)	0.339	8.80 (5.88)	0.219
	Post	6.33 (5.38)		7.47 (3.74)	
CSC Time	Pre	1.47 (1.41)	0.158	1.33 (1.35)	0.666
	Post	0.93 (0.96)		1.13 (1.41)	
CSC Receptive	Pre	3.27 (2.25)	0.056	2.87 (2.33)	0.348
	Post	2.20 (2.11)		3.27 (2.76)	
CSC Expressive	Pre	3.33 (1.91)	0.055	3.40 (2.10)	1.000
	Post	2.33 (1.91)		3.40 (2.10)	
CSC Personal Areas	Pre	2.67 (2.13)	0.832	2.40 (2.16)	0.442
	Post	2.53 (1.60)		2.07 (1.94)	
CSC Total	Pre	18.60 (9.00)	0.139	18.80 (10.74)	0.328
	Post	14.33 (8.76)		17.33 (10.43)	
SRSI – SA	Pre	8.18 (0.93)	0.057	8.00 (0.93)	0.016
	Post	7.36 (1.63)		7.27 (0.92)	
SRSI – RC*	Pre	7.57 (1.74)	0.630	7.27 (1.83)	0.623
	Post	7.36 (2.24)		7.87 (2.13)	
SRSI – SB	Pre	7.55 (1.60)	<0.001	7.78 (1.41)	<0.001
	Post	4.95 (2.47)		6.09 (1.99)	
SADI	Pre	7.00 (1.84)	0.026	6.87 (2074)	0.002
	Post	5.56 (1.70)		5.87 (2.07)	

Table 23. (continued)

Outcome Measure	Time	FTF (n=15)	P	TR (n=15)	P
PART – O	Pre	1.47 (0.68)	0.149	1.61 (0.47)	0.256
	Post	1.48 (0.23)		1.68 (0.46)	
PART – S+	Pre	7.07 (1.64)	0.851	7.10 (1.83)	0.451
	Post	7.27 (1.21)		6.94 (1.73)	
PART – WS	Pre	11.01 (4.33)	0.204	11.57 (3.96)	0.185
	Post	11.91 (3.11)		12.31 (4.01)	

P=statistical difference pre-post
*Do not want this to change pre to post
+ want this to be higher, not lower. May indicate more self-awareness

The average length of an EON-MEM session was approximately 30 minutes, with individual sessions ranging from five to 70 minutes. When subjects were not able to move on to the next content session, the researcher would review the previous week's material, which generally happened quickly and accounts for the five to 10 minute sessions. The average length of a FTF session was approximately 27 minutes, while a TR session was 30 minutes. During the EON-MEM, participants are taught 4-step process for remembering (WOPR) for four different types of information (number, future tasks, oral information, and written information). The number of strategies generated for the four different types of information addressed during the 9-week EON-MEM intervention, as well as the four strategies in WOPR increased after the program for all types of information and strategies, for both groups. The FTF group had statistically significant improvements in numbers, future tasks, and oral information, as well as and the write, organize, and picture strategies. The TR group had significant improvements in the all four types of information, numbers, future tasks, oral information and written information, as well as the four write, organize picture, and rehearse strategies. Table 24 displays the pre and post strategies for each group.

Table 24. EON-MEM Information Areas and Strategy Generation at Baseline and Follow-up

Strategy	Time	FTF (n=15)	P	TR (n=15)	P
Numbers	Pre	1.27 (0.59)	0.003	1.40 (0.74)	0.011
	Post	2.53 (0.99)		2.53 (1.25)	
Future Tasks	Pre	1.27 (0.46)	0.029	0.87 (0.52)	0.001
	Post	2.00 (0.93)		2.80 (0.94)	
Oral Information	Pre	1.00 (0.54)	0.027	0.93 (0.59)	0.007
	Post	1.73 (0.96)		2.40 (1.30)	
Written Information	Pre	1.20 (0.56)	0.107	0.93 (0.59)	0.028
	Post	1.67 (1.11)		1.73 (1.16)	
Write	Pre	2.73 (0.88)	0.064	2.13 (1.13)	0.023
	Post	3.20 (0.86)		3.07 (0.59)	
Organize	Pre	0.20 (0.41)	0.003	0.20 (0.41)	0.004
	Post	1.53 (1.25)		1.87 (1.51)	
Picture	Pre	0.67 (0.26)	0.003	0.27 (0.46)	0.002
	Post	1.33 (1.23)		2.07 (1.44)	
Rehearse	Pre	1.40 (0.83)	0.298	1.33 (1.29)	0.035
	Post	1.80 (1.15)		2.13 (1.36)	

5.3.2.3 Clinical Change

To determine if the FTF and TR interventions resulted in clinically significant changes, pre to post change scores were calculated, with the cut off scores for scaled scores and *t-scores* of -1 to +1 and -3.3 to +3.3, respectively, a priori. The FTF group change scores were 2.00 and 1.71 for WMS – Logical Memory I and WMS – Logical Memory II, respectively. The TR change score for WMS – Logical Memory I was 1.6 and 1.7 for WMS – Logical Memory II. Figure 19 displays the change scores, as well as the cut off score indicated by the black line, for the standard scores.

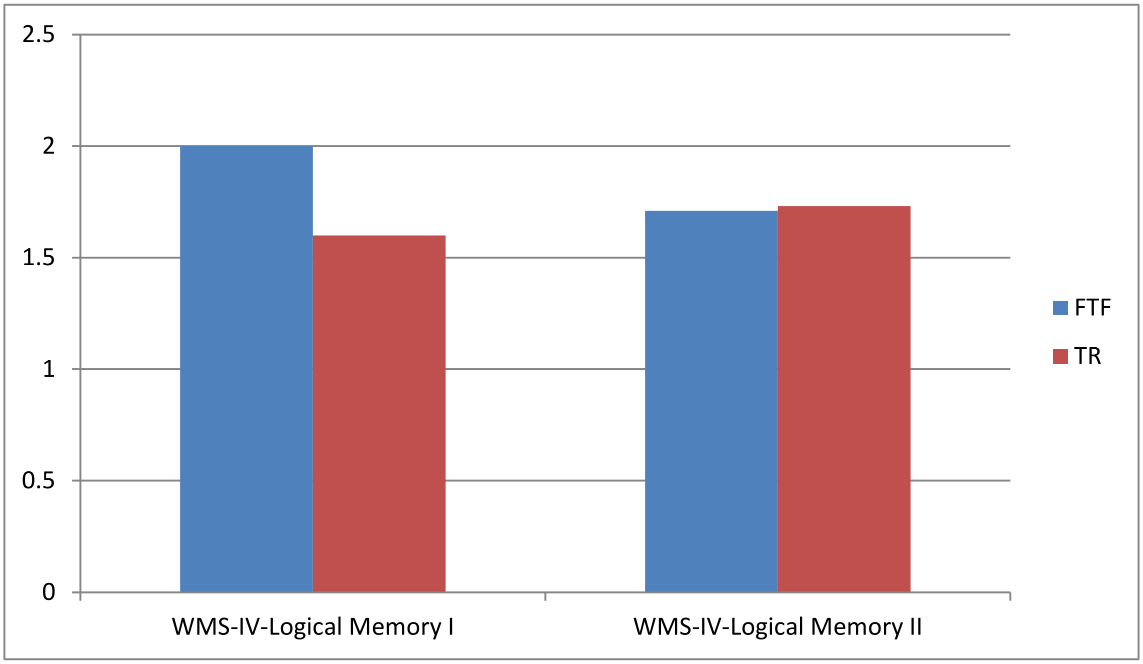

Figure 19. Clinical Change – WMS-IV Logical Memory

The FTF group WMS –Logical Memory II Recognition change was 1.90 and did not reach the expected change of 3.3, while the TR group changed a magnitude of 4.16. With respect to the MIsT Prospective Memory total, the FTF group changed a magnitude of 7.6 and the TR group a magnitude of 6.37, well above the expected change of 3.3. Figure 20 displays the change scores, as well as the cut off score indicated by the black line for the *t-scores*.

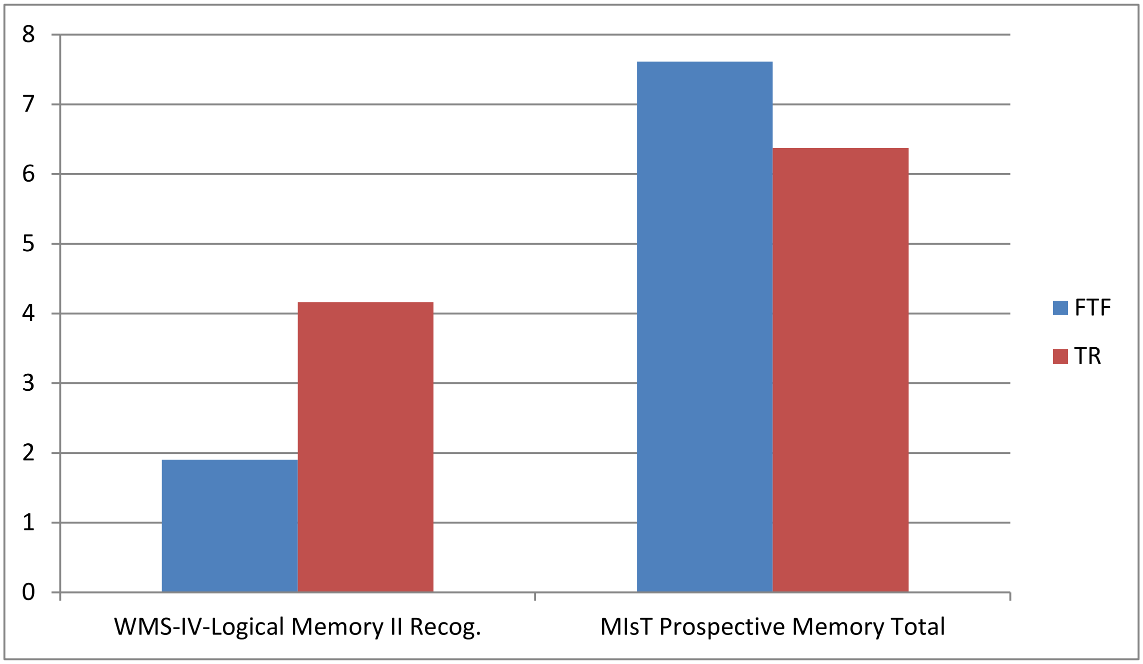

Figure 20. Clinical Change – WMS-IV Logical Memory Recognition and MIsT Prospective Memory Total

Relative change percent's were also calculated for the four objective memory measures. Relative change percent was calculated using the following equation: ((Post-Pre)/Pre)*100. Overall, the mean percent relative change for the FTF was approximately 27% in WMS – Logical Memory I while the mean percent relative change for the TR group was roughly 19% change as a whole. For, WMS – Logical Memory II and WMS – Logical Memory II Recognition, the FTF group the relative change percentages were approximately 43% and 6%, while the TR group relative change percentages were approximately 63% and 12%, respectively. Both groups also had similar changes in MIsT PMT, with the FTF group changing about 23% and the TR group roughly 40%. There were no significant differences in the degree of change for the objective measures between the FTF and TR groups. Table 25 displays the pre to post changes for the objective outcomes and Table 26 displays the pre to post changes for the self-report outcomes.

Table 25. Mean Change Scores – Objective Measures

Outcome Measure	FTF Change (Post-Pre)	TR Change (Post-Pre)	P
WMS-IV-Logical Memory I	2.00 (3.23)	1.60 (1.68)	0.676
WMS-IV-Logical Memory II	1.71 (2.33)	1.73 (1.67)	0.980
WMS-IV-Logical Memory II Recognition	1.90 (8.45)	4.16 (8.20)	0.471
MIsT Prospective Memory Total	7.61 (5.59)	6.37 (13.01)	0.217

Note: P= statistical difference between FTF and TR

Table 26. Mean Change Scores – Self-Report Measures

Outcome Measure	Directionality Expected	FTF Change (Post-Pre)	Change (Post-Pre)	P
EMQ	Negative	-15.20 (23.38)	-18.25 (22.63)	0.849
PRMQ (P)	Negative	1.60 (2.30)	2.00 (2.94)	0.825
PRMQ (R)	Negative	-1.80 (4.71)	-3.75 (4.27)	0.541
PRMQ (Total)	Negative	2.60 (6.07)	1.75 (7.37)	0.854
CSC ADL	Negative	-1.53 (6.00)	-1.33 (4.01)	.915
CSC Time	Negative	-0.53 (1.41)	-0.20 (1.37)	0.517
CSC Receptive	Negative	-1.07 (1.98)	0.40 (1.59)	0.034
CSC Expressive	Negative	-1.00 (1.85)	0.00 (1.00)	0.187
CSC Personal Areas	Negative	-0.13 (2.39)	-0.33 (1.63)	0.791
CSC Total	Negative	-4.27 (10.53)	-1.47 (5.60)	0.713
SRSI – SA	Negative	-0.82 (1.71)	-0.73 (1.03)	0.876
SRSI – RC	Negative	-0.21 (1.63)	0.60 (2.69)	0.337
SRSI – SB	Negative	-2.60 (2.09)	-1.69 (1.73)	0.213
SADI	Negative	-1.14 (1.70)	-1.00 (1.73)	0.825
PART – O	Positive	0.01 (0.57)	0.07 (0.45)	0.753
PART – S	Positive	0.20 (1.52)	-0.16 (1.23)	0.492
PART – WS	Positive	0.90 (2.50)	0.75 (2.08)	0.863

Note: P= statistical difference between FTF and TR

5.4 DISCUSSION

Overall, the results from this study indicate TR is an effective means in providing cognitive rehabilitation services remotely. Additionally, these results support previous research that TR interventions can result in significant improvements in function, like that of FTF cognitive rehabilitation (Bergquist et al., 2009; Bourgeois et al., 2007; Salazar et al., 2000).

Results from the combined intervention group indicate the shortened 9-week EON-MEM intervention significantly improved subject memory function as measured by standardized and self-report measures of memory function. These results also indicate that the shortened EON-MEM has the potential to provide meaningful strategies to individuals that can support improvements in everyday memory function. Clinical decision making regarding the number of sessions and the length of the program is given to the clinicians within the EON-MEM Therapist Guide. This study established the validity of a 9-week EON-MEM intervention for clients with memory difficulties.

Equivalence testing, as opposed to superiority testing, was established as the appropriate methodology to determine how the TR intervention faired when compared to the FTF intervention. Because the control group (FTF) was an active control, instead of a no-contact control group, it would have been challenging to prove statistically that the TR group was superior to the FTF group (Vavken, 2011). As a result, equivalence testing is a more appropriate choice. With respect to equivalency, posttest mean differences for the WMS – Logical Memory II (-0.42) and WMS – Logical Memory II Recognition (-0.88) fell within the expected range. However, WMS – Logical Memory I (-1.44) was just outside of the expected range from -1 to +1. The MIsT Prospective Memory Total posttest mean difference was also outside the range of -3.3 to +3.3 with -4.02. Additionally, the CIs for each measure were not exclusively contained within these ranges. These findings indicate that the FTF and TR interventions were not statistically equivalent. While the results from this study indicate the two interventions were not equivalent, the small sample size may limit interpretation of this analysis.

While results indicate the FTF and TR groups were not statistically equivalent, the 9-week intervention was effective as evidenced by the combined total group. When further analyses were completed individually, the FTF and TR groups also improved memory function as measured by standardized evaluations of memory, as well as self-report of memory. The FTF group improved in six outcome measures while the TR group improved in five outcome measures. Overall, the FTF and TR groups significantly improved in four common areas, WMS – Logical Memory I and II, strategy behaviors on the SRSI, and general self-awareness (SADI). The FTF group also saw significant improvements in the MIsT Prospective Memory Total and the EMQ. The TR group also experienced significant improvements in the self-awareness of memory deficits on the SRSI. The 9-week FTF and TR interventions did not have an impact on subject general self-awareness or participation. There were no significant improvements on prospective and retrospective memory (PRMQ) or in any of the areas measured by the cognitive symptom checklist. The EMQ and the PRMQ were introduced late during the clinical trial so the limited subjects for these two tools may impact the outcomes. The cognitive symptoms checklist asks subjects to rate if they have difficulty remembering any on five areas. While certain areas such as time and personal could have been impacted by participation in the 9-week memory intervention, the other areas (receptive language, expressive language) were not directly addressed. Several areas within activities of daily living such as food preparation sequence may be challenging for clients to apply in a timely manner. Additionally, because participants resided in a residential education facility, several of the areas were irrelevant to the group.

Possibly of greater importance for individuals with cognitive disabilities is clinical significance. While both groups statistically improved in some areas pre to post, individuals in the TR group also surpassed the cutoff score indicating clinical significance of the changes brought by the intervention. The FTF group experienced clinically significant improvements on the WMS – Logical Memory I and Logical Memory II, as well at the MIsT Prospective Memory Total, while the TR group experience clinically significant change in these areas, plus WMS– Logical Memory II recognition. This may be a function of TR subjects using the tablet and being required to plan and attend to the activity they were working on for the EON-MEM.

During the course of the EON-MEM administration, several subjects had difficulty with aspects of the teaching of WOPR, especially the picturing. Several subjects tended to be concrete and were unable to imagine a bizarre picture that may not make sense, and often did not work as a strategy as a reminder of a future task or appointment. In addition, when learning the peg system, some subjects preferred to say "bun o'clock" instead of rhyming one-bun. Due to some of these challenges, the EON-MEM may not be the most appropriate intervention for this population; however the FTF and TR groups still benefited from participation. More specificity, they benefited from what relevant content (memory) and not the general measures such as self-awareness and participation. Results indicate participation in the FTF and TR groups had no connection to participation; it solely impacted memory performance and subjective feelings about memory.

In general, it took subjects in the TR group longer to complete the weekly sessions with the researchers, as well as the homework activities than the FTF group; however this is a positive for the TR interventions. When FTF subjects missed any daily activity, whether one to four in any week, they could complete all of the activities in one sitting. This behavior defeats the purpose of repetition through daily homework activities. Individuals in the TR group were not permitted to complete more than one activity per day, even when they fell behind. Additionally, subjects in the TR group also completed less homework activities than the FTF group, on average. As a result, more people in the TR group tended to repeat a session due to lack of homework completion. Since strategies developed through cognitive rehabilitation require repetition and practice, it can be suggested that it is better for subjects to repeat a session and review the content, than rush through the activities without focusing on the strategy being reinforced.

There have been several studies that addressed the use of telephoning or videoconferencing with a clinician to deliver an intervention for persons with cognitive disabilities and they have been proven effective (Bell, Temkin, Esselman, Doctor, Bombardier, Fraser, et al., 2005; Bombardier, Bell, Temkin, Fann, Hoffman, & Dikemn, 2009; Palmer, Meyers, Vander Stoep, McCarty, Geyer, & DeSalvo, 2010). This study added a new TR component through the use of the tablet PC and Moodle to complete the cognitive rehabilitation activities.

There were several strengths to this study. Because this study was embedded into a larger cognitive rehabilitation program, researchers had access to a large convenience sample, as well as access to the subjects daily, over a 15 week period. Subject retention is typically challenging in long-term interventions, especially in the rehabilitation fields. As a result, using this group allowed the researchers to increase subject retention, as well as communicate with on-site clinicians to provide reminders to the subjects to complete their homework. Additionally, while the subjects differed in the nature of the cognitive disability, the overall groups tended to be homogenous with respect to functional level, however some higher functioning and lower functioning outliers were still present in the group. Regardless of the severity of cognitive disability and level of functioning, the subjects were randomized into an intervention group, thereby decreasing selection bias and provided a better opportunity to have similar groups.

Although this study had three researchers providing intervention to the subjects, steps were taken to minimize the differences in clinical presentation and abilities through weekly supervision and video review. This was considered acceptable since Stringer (2011) had four therapists administered the EON-MEM intervention according to the standardized protocol.

While subjects in the TR group completed fewer homework activities overall, subjects in this group may have benefited more from completing these activities because it was more difficult to cheat (i.e. not waiting through the 30-minute delay) and subjects were forced to try to remember the information pieces longer which resulted in greater fidelity to the intervention protocol. The protocol intends to fortify results by testing subject's long-term ability to remember pieces of information with distractions. While the majority of subjects reported to not waiting, or not completing the last question after the delay, most subjects in the TR group finished this question. Even though the tablet forces subjects to wait the 30 minutes, it may not be robust enough to detect through standardized measures used in this study.

Another interesting point for having the EON-MEM administered within a group cognitive rehabilitation program was that all subjects were going through the same intervention. As a result, some subjects had the opportunity to work with another subject if they were having difficulty with an activity. Although several of the answers were specific to the subject generated images, subjects could still work with another person to get their homework done, which may have increased motivation. Throughout Stinger's results, participants' working together was not discussed.

This study also had several limitations. First, the study sample size was small for the planned analyses of outcome measures. In general, the sample size needed for equivalence testing is substantially larger than needed for superiority testing due to the established magnitude needed to be considered as clinically significant is a smaller margin than in superiority studies (Vavken, 2011). Further, Christensen (2007) states that the typical sample size needed for equivalence testing is often four times the sample size of superiority testing. The established sample size for superiority testing conducted through a power analysis in this study was determined to be 42 subjects per group, or 84 subjects total. While equivalency was not established, it may not have a significant clinical impact as both interventions were found to result in significant improvements on clinical outcomes.

While having the memory intervention embedded into a larger general cognitive rehabilitation program served as a strength for subject retention, limitations were also presented. Because subjects were receiving broader cognitive rehabilitation services, it may be difficult to ascertain whether changes in memory performance were a result of the EON-MEM intervention, the larger program, or likely a combination of both interventions. Therefore, results from this study may not be generalizable to other populations or rehabilitation and community settings. However, this is less of a concern as subjects only changed on measures of memory function and awareness and usage of strategies to assist with memory.

Embedding the intervention within a broader group cognitive rehabilitation program was also a limitation as not everyone had profound memory impairments. Individuals with memory impairments would generally seek out an intervention such as the EON-MEM, and those who do not have memory impairments would not seek out an intervention such as the EON-MEM, so for our study population, the motivation may not have always been there to maintain engagement in the program. Some subjects were also upset they were not randomized into the TR group to use the tablet, so they sometimes presented as disengaged with paper and pencil method. This was also reinforced daily when other members of the group signed out the tablet and completed their homework next to each other. As a result, discussion on some of the homework activities occurred and a true representation of a person's ability might not be achieved.

Within the subject pool there was considerable heterogeneity. In general, the subjects in this sample were relatively low functioning, so improvements should be interpreted with caution as the results might not be generalizable to all persons with cognitive disabilities. Subjects in the study also varied on the level of self-awareness of their memory difficulties. While some subjects had fair memory ability, some subjects had very limited awareness of their strengths and weakness as related to memory. For individuals with limited memory self-awareness, challenges to get the person to buy into the usefulness of the strategies were sometimes encountered. The most prevalent cognitive disability was diagnoses on the autism spectrum. This group of subjects tended to have the most difficulty utilizing the WOPR strategies presumably due to the abstract nature of the picturing step. Individuals with an ASD diagnosis, in this study, tended to be concrete and have difficulty creating abstract images in their minds and may not have fully benefited from the 9-week EON-MEM intervention.

With respect to testing and outcome measures, the MIsT and WMS-LM-IV may not have been the best standardized tools to measure change in memory functioning. The EON-MEM did not teach strategies to impact the type of memory and learning that is assessed through these tools. As a result, future studies should include assessments that involve list learning such as the CVLT. Similar to the study conducted by Kaschel, et al. (2002) that used imagery as an intervention to remediate memory deficits, the limited changes in MIsT and WMS scores is not surprising. According to Kaschel et al. (2002), the results indicating limited benefits of imagery training as measured by standardized measures of memory such as the WMS or the Rivermead Behavioral Memory Test (RMBT) total score is not surprising for several reasons. First, the authors stated that in most subtests, images could not act as a retrieval cue. Additionally, if images could have been used, the time might have been too short to generate, store, and retrieve proper images and visual tests of memory may interfere with the generation of one's own image. The authors also state the recall of visual images or names of faces on RMBT might not be enhanced by the type of imagery training because their intervention aimed at the retention of verbal and prospective information only as opposed to retrospective recall. One additional concern is that standardized assessments may not effectively measure change in functioning (Kaschel, et al., 2002). In contrast, Thickpenny-Davis and Barker-Collo (2007) found memory training has a positive impact on selected neuropsychological tests, however, the authors did not expect change on these standardized measures. Similarly to Kaschel et al. (2002), Thickpenny-Davis and Barker-Collo (2007) stated their intervention was aimed to teach compensatory strategies that generally cannot be easily used on standardized measures as the subjects may not have enough time to generate a strategy to aid in remembering what they were asked to do.

There were also some technology related limitations to this study. Due to the version of Adobe Captivate that was used, some activities could not be designed to equally match the paper based materials. In addition, the technology didn't always work due to Internet outages and flash updates required on the tablets. Subjects were also not allowed to take their tablet with them to their dorm, so they did not use them as much as they could. It was originally planned to let the subjects keep the technology, but due to lack of wireless Internet in some subject's rooms, as well as the cost of the technology, the tablets needed to be kept in a safe place when not in use. One of the challenges included subjects completing the homework in order to move on to the next module. It was also originally planned to have the system on a smart phone and send reminders when they failed to log into the system for two consecutive days. Once the technology was moved to a tablet PC, the reminders were planned to be sent to the person's personal cell phone, however not all subjects had a cell phone or used it enough to be effectively prompted by the reminders. In general, it may not be feasible to conduct a long-term study that gives out tablets to subjects. Additionally, due to some of the limitations on the tablet PC, these remote cognitive rehabilitation courses delivered through a learning management system may be better suited for a desktop or a laptop computer.

The electronic activities designed through this intervention may better serve as an adjunct to a group cognitive rehabilitation program, as opposed to a standalone intervention. This project laid the ground work to adapt activities into an electronic format that a person may work on individually in a group program. This would allow group programs to further tailor to the needs of individual clients within the group. Future studies should include a larger, community based sample to address individuals in a more heterogeneous setting. This would allow for evaluation home based intervention and even further intervention in a naturalistic environment. Results could be strengthened if future studies evaluate a more homogeneous population. While individuals with ASD may not be the most appropriate group for this intervention, several disability groups in this study appeared well suited for this protocol, specifically TBI, SLD, and ADHD. Individuals with these disabilities particularly in the study were generally able to embrace the EON-MEM and discussed the benefits of the WOPR strategies with the group cognitive rehabilitation program clinicians. While individuals with ASD may not specifically benefit from the EON-MEM, other modules could be implemented using this remote cognitive rehabilitation system. Additional cognitive rehabilitation modules that may benefit individuals with ASD, as well as other cognitive disabilities, include planning and problem solving, appropriate social interactions, and self-awareness strategies. In addition to alternative cognitive rehabilitation protocols, modifications may need to be made to the technology if the individual has a co-occurring physical or sensory disability that may impact their ability to utilize the technology.

5.4.1 Implementing Remote Cognitive Rehabilitation in Clinical Practice

There are many factors to consider when deciding to implement this protocol into clinical practice. These pieces include the overall development of the protocol, the technology components, as well as the facilities or space needed and the personnel involved in the implementation.

5.4.1.1 Development

The first step in implementing a remote cognitive rehabilitation protocol would be the identification of suitable cognitive rehabilitation intervention(s). Each protocol should be evaluated for its relevancy to the target population, likely ease of creating an electronic version, and the overall structure of the activities to be delivered. If clinicians are interested in designing a remote cognitive rehabilitation protocol from the beginning, adequate time should be given to ensure the program can be developed appropriately and tested prior to actual implementation. Development in this case, took approximately a year and a half from conceptual phase to the initial testing and revisions to the system. Depending upon the complexity of the cognitive rehabilitation protocol, this time could be increased. Testing should also be conducted prior to implementation to ensure the clients are receiving appropriate activities, the activities work and there are minimal glitches in the presentation, and there is fidelity to the original activities.

5.4.1.2 Technology

Another concern that needs to be addressed early on in the implementation process is the identification of technology devises (software or hardware) to facilitate a remote cognitive rehabilitation protocol, as well as the overall costs of these components. This specific project utilized VISYTER, Adobe® Captivate®, Moodle™, and an Asus Eee Pad Transformer tablet PC. While Moodle™ is a free LMS, Adobe® Captivate® version 6 commercially costs roughly $240. The Asus was selected due to its relatively low cost (did not require a cellular signal and data plan). This decision was a tradeoff, as subjects required a dedicated wireless Internet connection in order to access the daily homework activities. This also meant that the subjects could only access the tablets while they were in the group room and could not take the technology with them to promote continued use of the device between sessions. Since tablets are becoming more accessible for everyday use, an inclusion criterion for remote cognitive rehabilitation may be access to a tablet for personal use. If tablets are purchased for the clients, a contingency plan should be in place if the technology becomes broken or is lost by the individuals.

5.4.1.3 Facilities

In order to meet individually with the research team, a private or dedicated TR office needed to be established with an Internet connected computer to access VISYTER and its servers. If the Internet or the network has a high security level, the clinicians may encounter difficulties downloading and installing software programs such as a videoconferencing system to connect with clients. If the clinicians intend to meet with the clients in their homes, an evaluation of an appropriate space in their environment should be conducted. If the clients will be travelling to their local clinic, an evaluation of the onsite clinic and their available technology should also be conducted. One benefit to conducting remote sessions is the possibility of an increase in the number of times or sessions a person could receive. Clinicians may be limited in ability to intervene with a client if restricted by travel. When using a TR application, a clinician may have the ability to meet with a client more frequently and increase the ability to work on strategies with a person. This could allow for a better continuity of care by providing additional follow-up between sessions, increased ability to troubleshoot if a strategy is not working, and monitoring of strategy usage. If the number of sessions is increased, within reason, the client may have the ability to better self-report troubles if the challenges are more recently experienced, as opposed to waiting a week between sessions.

5.4.1.4 Personnel

Another implementation consideration relates to staffing and staff time. This includes the additional time needed to diligently monitor these activities to ensure the client has access to the next appropriate activity. The main clinician(s) who is responsible for conducting the program with clients must be identified. These individuals should practice using the technology, as well as delivering remote sessions in the event modifications to approaches in discussing strategies with clients need to be made. For example, a clinician may have to describe in great detail what the client should do or provide an on screen example on the desktop that is running the videoconferencing program, as opposed to showing the client by demonstrating in person on their tablet. In this study, a maximum of eight subjects participated in the TR group at any given time and were enrolled as part of a closed group, meaning participants started at the same time. If clients enrolled at different times, it could create additional difficulties tracking the appropriate progress for each client. In addition to closed groups, clinicians may also benefit from limiting the number of clients to a maximum of 10 at any given time.

Aside from the time, space, and technology components of implementing a remote cognitive rehabilitation program, a protocol should also be designed to ensure appropriate technical and clinical support is available for both sides. Technology challenges will likely be encountered during a long-term clinical program, so appropriate support should be identified to mitigate these challenges as much as possible and to ensure a high level of continuity of services are provided to the remote client. There should also be a clinician on site to support the client if any clinical challenges arise during the session that could be followed-up once the remote session ends. While it is not impossible to implement a remote cognitive rehabilitation program into clinical practice, a thorough needs assessment should be completed to ensure there are adequate technology and clinical supports to facilitate a remote program.

5.5 CONCLUSION

Limited evidence is available on the efficacy of remote and automated cognitive rehabilitation programs for the remediation of cognitive deficits. This study evaluated the equivalency and efficacy of a TR 9-week cognitive rehabilitation program compared to a FTF 9-week cognitive rehabilitation program. Results indicate a mixed outcome with respect to equivalency, with half of the measures resulting in equivalent outcomes and half not meeting equivalence standards. While equivalency is still unknown, the efficacy of the clinical study was established. Both the FTF and the TR 9-week cognitive rehabilitation interventions resulted in statistical and clinically significant results after participation. Future studies need to be conducted to continue to evaluate the equivalency of these two interventions, as well as expand to a larger, community dwelling population.

6.0 SATISFACTION, CLINICAL USABILITY, AND TECHNICAL USABILITY DURING REMOTE COGNITIVE REHABILITATION

6.1 INTRODUCTION

Individuals with cognitive disabilities experience a range of functional limitations that may impact their ability to obtain functional independence, maintain social relationships, and maintain employment opportunities. Cognitive rehabilitation is a systematic, functionally oriented service of therapeutic cognitive activities and an understanding of the person's behavioral deficits (Berquist & Malec, 1997). Functional changes are achieved by directing cognitive rehabilitation services to reinforce, strengthen or reestablish previously learned patterns of behavior, or by establishing new patterns of cognitive activity or mechanisms to compensate for impaired neurological systems. A major goal of cognitive rehabilitation is to provide interventions that lessen the cognitive impairment itself, or to lessen the disabling effect of the cognitive impairments (Committee on Cognitive Rehabilitation Therapy for Traumatic Brain Injury, 2011a).

Rural and remote areas often have limited access to resources and to skilled professions trained to deliver specialized medical and rehabilitation services (Callas, Ricci, & Caputo, 2000). Further, access to rehabilitation service is more difficult for individuals with disabilities who live in rural locations, compared to metropolitan areas (Demiris, Shigaki, & Schopp, 2005). Barriers to rehabilitation services for rural areas include distance to facilities, limited or lack of transportation, rural poverty, and lack of rural service providers (Schopp, Johnstone, & Merrel, 2000). As a result, individuals with disabilities may not receive the appropriate level of care due to the lack of access to specialty services and to new technologies (Johnstone, Nossaman, Schopp, Holmquist, & Rupright, 2002). Research has also found the greater the distance individuals must travel to obtain services, the less likely people are likely to receive that service (Johnson, Weiner, & Richardson, 1998).

Telerehabilitation (TR) uses telecommunication technology to facilitate rehabilitation services to those who may not have direct access (Russell, 2007). TR services may include consultations, homecare, monitoring, therapy, and direct patient care delivered to locations including, work settings, home, community, nursing homes and other health care facilities (Seelman & Hartman, 2009). TR has the capacity to provide health care services in rural areas, enlarge rehabilitation opportunities for clients by using computer-aided systems, improve quality of life, reduce medical costs, and reduce travel time (Rogante, Grigioni, Cordella, and Giacomozzi, 2010; Enger, Phillips, vora, & Wiggers, 2003; Torsney, 2003; Zheng, Black, & Harris, 2005; Park, Peng, & Zhang, 2008). Access to services is important, however if people are unsatisfied with the technology and the services they receive remotely, they ultimately may not utilize the services.

In order to evaluate individuals with disabilities reaction to remote interventions, Ricker, Rosenthal, Garay, Deluca, Germain, Abraham-Fuchs, et al. (2002) conducted a TR needs assessment for individuals with acquired brain injury (ABI). Results from this study revealed individuals with ABI have an interest in accessing TR services, especially in services that could address problems in memory, attention, problem-solving, and activities of daily living.

Additionally, Bergquist, Gehl, Mandrekar, Lepore, Hanna, Osten, and Beauliwu (2009) conducted a remote cognitive rehabilitation program for individuals with traumatic brain injury. Fourteen individuals completed 60 remote sessions and results showed significant improvements in memory and compensatory strategy utilization. As a follow up to the clinical study, Bergquist, Thompson, Gehl, & Pineda (2010) evaluated participant satisfaction after receiving remote cognitive rehabilitation. Results indicated individuals with TBI are interested in remote services and had a high level of satisfaction with the TR services received.

As a function of the systematic review, Kairy et al. (2009) evaluated the satisfaction evidence available for TR. An overall result indicated that satisfaction with TR is consistently high and was generally rated more favorable by the clients, rather than the clinicians delivering the services. One limitation to this systematic review is the limited availability of studies evaluating TR. Additional studies need to be conducted to determine satisfaction with remote cognitive rehabilitation services.

6.1.1 Research Aims

As a result of the limitations of systematic reviews analyses of telerehabilitation usability, the overall aim of this study was to measure subject satisfaction using TR to access cognitive rehabilitation remotely. The primary study objective included evaluation of the subjects' satisfaction with the TR application and technology as measured by the Telehealth Usability Questionnaire.

Hypothesis 1: The TR system will be rated by subjects as a usable and an accessible modality for cognitive rehabilitation.

6.2 MATERIALS AND METHODS

6.2.1 Instrumentation

As part of the remote cognitive rehabilitation services described in Chapter 6, subjects were asked to rate their level of satisfaction with the technology and the services receiving using TR. The versatile and integrated system for telerehabilitation (VISYTER) was selected as the videoconferencing system and was intended to replicate FTF meetings between the clinician and the client (Parmanto, Saptono, Pramana, Pulantara, Schein, Schmeler, et al., 2010). An Asus Eee Pad Transformer equipped with access to Moodle for completion of the daily homework activities, which was a component of the cognitive rehabilitation program. After subjects completed all cognitive rehabilitation activities, six usability questions were asked to the TR subjects. Each statement was graded on a 7-point Likert from 1 (Strongly Agree) to 7 (Strongly Disagree). In addition to these statements, two open ended questions regarding their desired changes and additions to the system were solicited. Lower mean scores on the satisfaction questionnaire indicate a higher degree of usability and satisfaction.

The Telehealth Usability Questionnaire (TUQ) was used to structure an interview that focused on the subjects' current needs, preferences, and goals to be achieved from using the system and their desire to use TR services again. The TUQ is a tool designed by the University of Pittsburgh and is based upon a number of different usability questionnaires, including the Post-Study System Usability Questionnaire (PSSUQ) (Lewis, 1993). The TUQ asks subjects to respond on a 7-point Likert from disagree (1) to agree (7). Higher scores (means) on the TUQ indicate a higher degree of usability. The TUQ asked subjects to rate both the clinical interactions over VISYTER, as well as their reactions to completing homework activities on a tablet PC. The TUQ also produces an overall usability score, as well as Usefulness, Ease of Use, Effectiveness, Reliability, and Satisfaction constructs. Overall scores and construct scores were computed by taking the average of total questions answered, as well as specific questions that reflect each construct. Questions reflecting the Usefulness construct were not asked, and as a result, were not computed for clinical usability. Institutional review board approval was obtained through the University of Pittsburgh prior to the clinical and technical usability study.

6.2.2 Research Subjects

A nonprobability convenience sample in which consecutive sampling, (all subjects who meet the criteria are recruited as they became available), was used. Fifteen subjects who received cognitive rehabilitation remotely participated in this study. Inclusion criteria included: primary disability was a result of a cognitive disability (i.e., primary impairment should be result of cognitive disability), expressed self-report difficulties with memory, expressed interest in improved functional status in independent living or employment, and native English speaking. Exclusion criteria included: Individual who possessed a primary mental health/psychiatric disability and demonstrated recent psychiatric symptomology, was actively using illegal drugs or using alcohol to excess, and non-native English speaking.

6.2.3 Research Procedures

Subjects completed the 9-week cognitive rehabilitation program detailed in Chapter 6. Each subject met weekly with a cognitive rehabilitation specialist over VISYTER, which was used to replicate face-to-face meetings. Additionally, each subject was provided with an Asus Eee Pad Transformer tablet that contained daily homework activities which they were instructed to be completed between weekly meetings. The tablets were equipped with a Wi-Fi connection and subjects accessed the homework activities through Moodle, a learning management system. Each subject participated in a minimum of 9 weekly sessions, and completed anywhere between 21 and 35 homework activities. At the conclusion of the remote cognitive rehabilitation program, subjects completed follow-up testing that included the TUQ. In addition to the TUQ, subjects were asked to describe their overall reaction to the TR services received through VISYTER and the activities completed on the tablet.

In addition to the clinical usability measured by the TUQ, technical usability was also evaluated. Technical usability was evaluated through incident logs as issues arose during the course of the remote cognitive rehabilitation. Information gathered for technical usability is descriptive in nature and documents technical challenges and problems.

6.2.4 Analysis

Due to the exploratory nature of this research study, descriptive statistics were run for data collected. Mean TUQ scores, as well as the range of responses, were calculated for each item and for the overall construct scores. Items were rated as usable if the mean score obtained was at least 4.0 (median score on 7-point Likert scale). Qualitative feedback was also analyzed for overall reactions toward the TR services and remote cognitive rehabilitation. Additional separate analyses were conducted to determine the usability of the technologies for conducting the remote sessions (VISYTER) and the daily activities (Tablet and Moodle). SPSS version 21 was used for statistical analysis.

6.3 RESULTS

6.3.1 Clinical Usability

The TUQ and the TR satisfaction questions were analyzed for all 15 subjects who received remote cognitive rehabilitation. Subjects who completed the remote cognitive rehabilitation program were 20.11±1.61 years. Sixty percent of the study population were male (n=9) and 40.00% were female (n=6), with 66.67% of the study population being Caucasian (n=10), 20.00% African American (n=3), and 13.33% Hispanic (n=2). The primary disabilities identified by a cognitive rehabilitation team during the remote cognitive rehabilitation study included 6.67% traumatic brain injury (n=1), 20.00% attention deficit hyperactivity disorder (n=3) , 26.67% learning disorders (n=4), and 40.00% autism spectrum disorders (including Asperger's, pervasive developmental disability, and autism) (n=6), with 6.67% having a diagnosis of other cognitive disorder (n=1). Most subjects had one (33.33%) or two (53.33%) cognitive diagnoses, while 13.33% of the subjects had three diagnoses identified in their records.

Results from the TUQ indicate variability in the satisfaction and usability of TR for the delivery of remote cognitive rehabilitation. Mean TUQ scores on individual items, as well as construct scores are displayed in Table 27. Subjects rated I can easily talk to the clinician using the telehealth system (6.13), I can hear the clinician clearly using the telehealth system (6.07), and overall, I am satisfied with this telehealth system (6.07) with the highest degree of satisfaction. In general, the lowest individual items included Whenever I made a mistake using the system I could recover easily and quickly (4.21), This system is able to do everything I would want it to be able to do (4.67), and Telehealth is an acceptable way to receive healthcare services (4.87). Although several items were rated as completely disagree by subjects, the overall usability scores for each item were above the median point (4), indicating that the system was still rated as usable. With respect to construct scores, Ease of Use, Effectiveness, Satisfaction, and Total Scores all were similar with a mean rating between 5.50-5.67. Only reliability scored low with a mean score of 4.77.

Table 27. Telehealth Usability Questionnaire Scores

System Component	**TUQ Question Mean (Standard Deviation)**	**Min**	**Max**	**Clients (n=15)**
Tablet	It was simple to use this system	1.00	7.00	5.47 (2.17)
Tablet	It was easy to learn to use the system.	2.00	7.00	5.93 (1.75)
Tablet	I believe I could become productive quickly using this system	2.00	7.00	5.93 (1.53)
Tablet	The way I interact with this system is pleasant.	1.00	7.00	5.20 (2.04)
Tablet	I like using the system.	1.00	7.00	5.40 (2.10)
Tablet	The system is simple and easy to understand.	3.00	7.00	5.67 (1.59)
Tablet	This system is able to do everything I would want it to be able to do.	1.00	7.00	4.67 (2.44)
VISYTER	I can easily talk to the clinician using the telehealth system.	4.00	7.00	6.13 (1.25)
VISYTER	I can hear the clinician clearly using the telehealth system.	3.00	7.00	6.07 (1.39)
VISYTER	I felt I was able to express myself effectively.	1.00	7.00	5.80 (1.97)

Table 27. (continued)

System Component	TUQ Question Mean (Standard Deviation)	Min	Max	Clients (n=15)
VISYTER	Using the telehealth system, I can see the clinician as well as if we met in person.	1.00	7.00	5.47 (2.07)
VISYTER	I think the visits provided over the telehealth system are the same as in-person visits.	1.00	7.00	5.13 (2.23)
Tablet	Whenever I made a mistake using the system, I could recover easily and quickly.[1]	1.00	7.00	4.21 (2.45)
VISYTER	I feel comfortable communicating with the clinician using the telehealth system.	1.00	7.00	5.93 (1.87)
Nonspecific	Telehealth is an acceptable way to receive healthcare services.	1.00	7.00	4.87 (2.13)
Nonspecific	I would use telehealth services again.	1.00	7.00	5.40 (2.38)
Nonspecific	Overall, I am satisfied with this telehealth system.	1.00	7.00	6.07 (1.94)
	Ease of Use	2.67	7.00	5.60 (1.37)
	Effectiveness	2.40	7.00	5.67 (1.57)
	Reliability	1.00	7.00	4.77 (2.31)
	Satisfaction	1.00	7.00	5.57 (1.91)
	Overall Score	2.35	7.00	5.50 (1.57)

Key: 1. n=14

6.3.1.1 VISYTER Usability

Six TUQ questions pertained specifically to the use of VISYTER during remote cognitive rehabilitation. Overall, VISYTER was found to be a useable system for delivering cognitive rehabilitation remotely. The mean scores on TUQ VISYTER specific questions ranged from 5.477 to 6.13. The VISYTER usability questions yielded a mean overall usability of 5.76±1.64.

6.3.1.2 Tablet Usability

Eight TUQ questions pertained specifically to the use of VISYTER during remote cognitive rehabilitation. Overall, the Asus Eee Pad Transformer and Moodle were found to be a usable system for automating cognitive rehabilitation activities. The mean scores on TUQ that were tablet specific questions ranged from 4.21 to 5.93. The Tablet specific usability questions yielded a mean of 5.33±1.56. In general, the mean tablet specific questions scored lower than the VISYTER questions. This may be a function of the frequency of the tablet usage (daily) compared to using VISYTER (weekly). Table 28 displays qualitative feedback from each participant as collected on the TUQ.

Table 28. Qualitative Usability Feedback

Client	Feedback from the Telehealth Usability Questionnaire
RCR1	No Comments
RCR2	No Comments
RCR7	Not as good as doing it in person. I learn a lot better with an actual teacher. There were too many errors with the system and it was hard to understand the person. I tried cyber school and I didn't like it. It was a good break from the rest of CSEP. There were too many glitches, it messed up a lot, and the tablet was too touchy
RCR8	I really liked using the tablet for learning. It might be some of the strategies for when I get into a training program. I'll know what to do and how to do it.
RCR12	The audio stinks - feedback. I didn't like seeing myself
RCR13	I really enjoyed using the telehealth system, but I wish that I could open two programs at once when needed (i.e. SHRS/Super Note)
RCR15	I really liked the tablet and preferred it over the paper and pencil. The tablet was slow at times
RCR17	The computer worked better and was more comfortable than the tablet. I would do it all on the computer
RCR18	I didn't like the memory training at all. No comments
RCR19	Echo Speakers
RCR21	Besides the visual content, there were a lot of times when it would freeze or fragment. Audio was fine though
RCR29	No Comments
RCR30	No Comments
RCR31	Tablet was slow loading sometimes
RCR37	I don't like communicating over the computer, I like communicating in person. It feels more private

In addition to the TUQ, overall satisfaction with specific pieces of the TR process was solicited by 13 subjects. Overall results from the TR satisfaction questionnaire indicate a high level of satisfaction with mean scores ranging from 1.77 to 3.15. Interestingly, responses to the question – there were things I was unable to do because of the computer system that I would have been able to do using a paper and pencil received a mean score of 4.08 indicating a lower level of usability.

Table 29. Telehealth Satisfaction

Measure	**Range**	**Mean (St. Dev.) (n=13)**
I felt comfortable completing the homework activity using the tablet computer	1-7	2.15 (1.72)
I felt comfortable meeting with the memory therapist using the computer.	1-4	1.77 (1.17)
The quality and clarity of the video (picture) was acceptable.	1-6	2.54 (1.85)
The quality and clarity of the audio (sound) was acceptable.	1-6	2.77 (1.96)
There were things I was unable to do because of the computer system that I would have been able to do using a paper and pencil.	1-7	4.08 (2.25)
If I had to have rehabilitation services in the future, I would be willing to do them over the computer.	1-7	3.15 (2.12)

6.3.2 Technical Usability

Technical usability was also measured during the course of the remote memory training. During the memory training, remote subjects experienced several challenges with VISYTER and with the tablets. On two occasions, there were internet outages due to weather and to other service interruptions that impacted the subjects' ability to complete their homework for that day. On one homework activity, subjects reported not being able to hear the audio that was being played. The tablets and the activity were checked and found to be present in the file, but the sound could not be played on the tablets. This may have been due to the large file size for this activity. Sound was operational for the other activities. Early on in using the tablets, the activities became unresponsive in Moodle, or would not load due to the flash player needing updated. This prevented subjects, on occasion, from completing their homework until the flash player was updated.

The main technical usability concern arose toward the end of the spring testing period. In previous terms, the tablets were wiped clean by completing a factory reset to erase any subject information prior to reusing the tablet with another subject. The tablets would then be set up to support Moodle by downloading Adobe Flash Player in the Google Play Store. During the last round of cleaning the tablets, a problem was discovered during the initial set up to reestablish an operational tablet. Google is no longer supporting Adobe Flash Player on Android tablets and, as a result, is no longer available for download in Google Play. The tablets needed to be evaluated by a technical support person in order to determine if Adobe Flash Player could be manually restored.

With respect to using VISYTER as a part of the remote cognitive rehabilitation system, there were also several issues that occurred during the remote memory training. When preparing for remote sessions, the servers that host the VISYTER Internet Protocol addresses experienced a connection outage so there was difficulty establishing a remote connection to conduct the remote sessions. During the sessions, the researchers could benefit from having a second camera on the remote side to see tablet and what the subject was doing during the session; however, this could not be supported with Internet strength in one location. During one specific session early on in the groups, the video froze three times in one session. In a few other sessions, the sound froze or would cut out. It was determined the sound issue was due to a speaker hardware problem on one occasion, and Internet issues on the subsequent times.

With respect to the technical usability, subject also provided qualitative feedback about different technical component. Table 30 displays the open ended feedback from subjects solicited from the telerehabilitation satisfaction questionnaire.

Table 30. Qualitative Technical Usability

Measure	Qualitative Feedback
Homework on tablet	• It was hard because sometimes it didn't do anything when you pressed a button. "Touchy" • Was a little hard to get used to at first • Moodle is terrible, the tablet was okay
Comfortable meeting over computer	• It was different - in a good way. Liked that they could see each other. Not as nervous
Quality of picture	• Internet
Quality of audio	• Sometimes echoing or time-delayed
Unable to do things	• Remembering stuff was harder on the tablet. Keyboard didn’t pop up sometimes • Waiting. All the homework • Getting everything done on time was hard because sometimes it wasn't working well
Would be willing to have rehabilitation services over computer	• Sometimes may be easier in person (e.g. could show you the button/what to do rather than tell you). • Paper is easier, face to face is better for therapy because she can be in the same room. • Easier in person • First experience, not sure how comfortable with other rehab services
Changes	• Less waiting periods • So sensitive to the touch, couldn't complete tasks because it didn't work at first but then skipped two • Tech difficulties • Acronyms and acrostics were difficult on the tablet • Better audio • Have therapy items in room for other rehab services • No echo speakers • Clarity of the video meeting • Try to find a better site than Moodle - Google plus account would be better; Moodle is "lagtastic" - slower than a snail and it "bugs out • Pretty good the way it was. Tablet was slow loading sometimes
Additions	• More/better sound • Better screen • More hints

6.4 DISCUSSION

Results from this study indicate that subjects were mixed in their reactions to the TR delivery. While Kairy et al. (2009) and Bergquist et al. (2010) found a moderately high level of satisfaction using TR technologies; results from this study indicate mixed usability results. Additionally, usability results during the clinical trial indicate lower scores than during formative usability testing. This is likely due to the subjects having to use the technology over a longer period of time when things could not function as well. For the purpose of this usability study, clients were asked to rate their satisfaction with both the tablet, as well as the weekly remote meetings conducted over VISYTER. Some clients rated being dissatisfied with the remote meetings. As a result, it may have biased the satisfaction ratings for the tablet. Subjects rated the ability to recover quickly as the lowest (4.21). This score may reflect the actual cognitive rehabilitation assignments and not the electronic activity presented on the tablet. This could also be a result of some of the cognitive challenges associated with cognitive disabilities. Additionally, some subjects were frustrated with the 9-week EON-MEM in general which may have biased their response to the question regarding if telehealth is an acceptable way to receive healthcare services (4.71). Some subjects may not have been able to separate their dislike for this intervention and generalize it to telehealth services in general.

Qualitative data also indicates mixed results on the overall usability of the system. One subject stated they did not feel that the remote cognitive rehabilitation was as good as doing in person. However, other subjects stated they believed that completing the activities on the tablet was better than doing it using paper and pencil. Overall, however, clients still rated the overall usability of the system as high (5.50), indicating that even with glitches in the system, it was still a usable means to deliver cognitive rehabilitation services. Since subjects rated there were things they were unable to do because of the computer system that they would have been able to do using a paper and pencil on the TR satisfaction survey as low, future versions may need to address this concern. One hypothesis about this concern is the lack of integration between Moodle and an open workspace (notepad) where the participant could write notes while they were working. This is a limitation of the system used to create the activities and of Moodle™. Future remote cognitive rehabilitation programs should evaluate alternative ways to allow participants to multitask while completing activities.

During their participation in the 9-week cognitive rehabilitation program, subjects did experience technical difficulties including Internet outages or slowed speeds, as well as slow response time when clicking an icon on the tablet. As a result, some subjects expressed higher levels of frustration with the technology than other subjects. During weekly sessions, some subjects experienced a speaker echo when trying to communicate with the cognitive rehabilitation specialist. Additionally, VISYTER froze on occasion during some sessions, requiring an on-site technician to enter the room and restart the system, disrupting the clinical session. Another confound for the TR delivery resulted from several clients disliking memory training in general, which may have biased other results of the TUQ.

With respect to the tablet, some clients had internet connectivity issues and were unable to complete homework assignments. Feedback regarding the tablet indicated the tablet was touchy and clients had to tap items multiple times. One subject recommended completing all components of the memory training on the computer, as opposed to using the computer and a tablet. Additionally, some subjects enjoyed using the tablet, while other people did not like the tablet. One subject attended cyber school, however preferred attending school in person. As a result, this client stated it was better to do things in person. Although some subjects had negative feedback regarding the TR delivery, the average feedback was positive. One client stated they enjoyed the tablet and preferred it over paper and pencil. Another subject stated they really liked using the tablet for learning purposes. This subject also stated they could use some of the memory strategies and how to use a tablet for when they get into their training program.

The present study had certain limitations. The TUQ may not be a proper tool for subjects with cognitive disabilities. The TUQ asks individuals if they believe that telehealth is an acceptable way to receive healthcare services and if they would use telehealth services again. These questions may be misinterpreted by individuals with cognitive disabilities without proper clarification. Future studies should identify appropriate satisfaction tools for individuals with cognitive disabilities.

6.4.1 Technical Usability

Due to technical difficulties with some of the components, caution should be taken when recommending a technology device. Advancements and improvements of technology devices happen rapidly in today’s shifting market. While this is beneficial because it drives down the cost of device, it can also create unforeseen challenges with running a long-term clinical study. When considering a piece of technology for a long-term clinical study, research needs to be conducted on products to ensure is not scheduled to be released early on in the project which might make the support for current devices obsolete. Additionally, when devices are provided to participants for long periods of time, proper training on updating the technology needs to be provided as new versions of required operating system components may cause fatal errors in the operation of cognitive rehabilitation applications.

6.5 CONCLUSION

While some clients expressed frustration with the tablet, the overall system was still deemed usable and most subjects were satisfied with the tablet, as well as the weekly sessions conducted over VISYTER. Results from this study indicate that TR, which includes videoconferencing systems and learning managements systems, is an acceptable way to deliver cognitive rehabilitation services and adults with cognitive disabilities are willing to receive remote services.

7.0 SUMMARY

Individuals with cognitive disabilities experience deficits in cognitive function, especially in memory. While cognitive rehabilitation is a means to mitigate the functional deficits resulting from cognitive disabilities, access to these specialized services can be challenging for individuals who live in nonmetropolitan areas. As a result, a remote cognitive rehabilitation system was designed to deliver cognitive rehabilitation remotely to participants. The Ecologically Oriented Neurorehabilitation of Memory (EON-MEM), a manualized approach to delivering cognitive rehabilitation, was selected as the cognitive rehabilitation protocol to be modified for delivery through a cognitive rehabilitation system.

A cognitive rehabilitation system that included a *videoconferencing* component and a *remote cognitive rehabilitation application* system were developed. The versatile and integrated system for telerehabilitation (VISYTER) was selected as the videoconferencing modality. The EON-MEM content was converted into an electronic format and loaded into a learning management system and was delivered remotely to subjects on a tablet PC. During development, formative and summative usability studies were conducted to ensure the remote cognitive rehabilitation application system had all the necessary components and the electronic EON-MEM content kept a high fidelity to the original paper content.

The finalized system was deployed into a clinical trial evaluating the efficacy and equivalency of face-to-face (FTF) and telerehabilitation (TR) interventions. Thirty subjects with cognitive disabilities participated in the clinical trial, 15 FTF and 15 TR. Results from the clinical study indicate that both FTF and TR interventions resulted in statistically and clinical significant changes after participating in cognitive rehabilitation interventions. FTF and TR Equivalency was established for two of four measures, indicating further study is needed to fully establish equivalency of the two interventions.

During the clinical trial, the TR subject rated the system satisfactorily and indicated it is a usable system for the delivery of remote cognitive rehabilitation services. While some subjects rated the memory training intervention itself neutrally or negatively, the overall usability and satisfaction with the TR services was high, as rated by the subjects and by researchers experienced at providing cognitive rehabilitation services. Most individuals reported they would use TR services again. Overall, the results from these studies indicate that telerehabilitation (TR) is an acceptable way to deliver cognitive rehabilitation services to individuals with cognitive disabilities, remotely.

APPENDIX A

LITERATURE REVIEW OF MEMORY CHANGES AFTER INTERVENTION

Article	Sample Size	Measure	Pre	Post	% Change ((Post-Pre)/Pre)*100
Thickpenny-Davis and Barker-Collo (2007)	12 individuals with TBI and CVA Wait list: pre=7, post=3 No wait list: pre=7, post=6 Stats appear that they combined groups to conduct pre/post analyses	CVLT Trial 1 (z-scores)	-1.33 (1.03) -1.57 (0.53)	-1.33 (1.15) -1.33 (0.82)	0 15.3%
		Trial 5	-4.33 (1.03) -3.86 (1.86)	-4.33 (1.15) -3.86 (1.94)	0 0
		List B	-2.33 (1.03) -2.43 (0.53)	-2.33 (1.52) -1.83 (0.75)	0 24.7% (p=0.053)
		Short delay free	-3.33 (1.21) -4.00 (1.83)	-4.00 (1.0) -3.33 (1.86)	-20.1% 20.1%
		Short delay cued	-3.00 (1.41) -3.86 (1.77)	-3.67 (1.15) -3.17 (1.83)	-22.3% 17.9% (p=0.007)
		Long delay free	-3.50 (1.05) -3.71 (1.80)	-3.67 (1.53) -3.00 (2.28)	-4.9% 19.1%
		Long delay cued	-3.33 (1.37) -3.86 (1.86)	-4.00 (1.00) -3.50 (2.07)	-20.1% 9.3%
		Recognition	-2.00 (1.55) -1.43 (1.90)	-4.00 (1.00) -1.67 (1.03)	-100% -16.8%
		False Positive	-2.17 (1.09) 2.86 (2.27)	-2.00 (1.73) 1.83 (2.48)	7.8% 36.0%
		Visual Paired Associates Immediate (z-scores)	-2.17 (1.09) -2.32 (1.44)	-1.39 (1.28) -2.39 (2.18)	35.9% -3.0%
		Visual Paired Associates Delayed (z-scores)	-2.05 (1.09) -4.05 (3.26)	-1.95 (2.06) -3.01 (2.74)	4.9% 25.7%
		LM Immediate (z-scores)	-1.72 (0.44) -1.62 (0.78)	-1.55 (1.13) -1.36 (0.78)	9.9% 18.5% (p=0.067)
		LM Delayed (z-scores)	-1.57 (0.56) -2.29 (0.68)	-1.37 (1.32) -1.91 (0.55)	12.7% 16.6% (p=0.009)
		Everyday Memory Questionnaire (raw scores from 0 – 72, ↑ better)	46.00 (11.78) 39.29 (14.21)	52.00 (15.62) 40.17 (18.82)	13% 2.2%

Article	Sample Size	Measure	Pre	Post	% Change ((Post-Pre)/Pre)*100
Kaschel, et al. (2002)	2 different intervention groups 12 and 9 people with memory impairments –	WMS	66.4 (7.1) 68.0 (10.8)	67.3 (6.9) 70.3 (14.7)	1.4% 3.4%
		RBMT Profile Score	19.7 (3.2) 21.0 (3.8)	19.2 (3.2) 20.1 (4.5)	-2.5% -4.3%
		Story Immediate	9.4 (3.3) 11.2 (3.1)	9.1 (2.1) 14.1 (4.5)	-3.2% 25.9% (p=0.0125)
		Story Delayed	8.1 (3.8) 10.4 (2.8)	7.6 (2.8) 13.3 (4.5)	-6.2% 27.9% (p=0.011)
		Metamemory questionnaire (Memory Assessment Clinics Rating Scales)	87.0 (11.7) 75.0 (14.8)	89.8 (10.3) 82.7 (13.8)	3.2% 10.3% (p<0.0095)
Quemada, et al. (2003)	12 individuals with TBI Results: the authors claim participants increased in functional ability – “All patients achieved meaningful gains but did not correlate with improvement in memory process.”	CVLT (# words recalled) AONE AFIVE SDFR LDFR DI	 4.2 (1.3) 29.4 (9.0) 3.0 (2.1) 2.9 (2.7) 79.0 (11.1)	 6.0 (3.3) 37.5 (12.0) 4.8 (3.1) 5.2 (2.6) 82.5 (10.5)	 42.9% (p=0.03) 27.6% 60% (p=0.09) 79% (p=0.05) 4.4%
		REY	9.5 (5.3)	11.9 (4.9)	25.2%
		RMBT (screening score 0-12)	4.8 (3.2)	5.7 (2.7)	18.8%
		Memory Functioning Everyday (Score ranges 0-56, ↓better)	17.8 (12.3)	18.7 (10.6)	5.1%
Raskin and Sohlberg (2008)	8 Individuals with TBI	Prospective Memory Questionnaire	12.23 (7.47)	9.13 (3.87)	-25.3%
		Everyday Memory Questionnaire (↓better)	19.83 (8.22)	16.22 (4.21)	-18.1% (p<0.01)
		AIM (MIsT precursor)	42.33	48.10	13.63% (p<0.01)
Tam and Man (2004)	4 intervention groups + control group 6-8 individuals with TBI in each group “All four memory training methods showed positive among the persons with TBI, although not stat. significant”	Rivermead Behavioral Memory Test	9.43 (4.65) 8.28 (5.56) 14.17 (4.67) 9.50 (6.38) 11.75 (2.31)	10.43 (6.02) 8.14 (7.15) 12.50 (3.83) 12.83 (6.31) 12.50 (2.39)	10.6% -1.7% -11.8% 35.1% 6.4%

Article	Sample Size	Measure	Pre	Post	% Change ((Post-Pre)/Pre)*100
Fleming, et al. (2005)	3 people with TBI 3 case studies presented. Results state "The results from this study indicate a general improvement in PM function and diary use." No stats	MIsT	24 45 35	30 48 48	25% 6.7% 37.1%
		CAPM – BADL	1.6 1.2 1.3	1.5 1.2 1.6	-6.25% 0 23.1%
		CAPM – IADL	2.3 1.7 1.6	1.9 2.0 1.3	-17.4% 17.6% -18.75

APPENDIX B

SELF-REGULATION SKILLS INTERVIEW

Self-Regulation Skills Interview
Screening question: ‘‘Think about the various ways that you may have changed since your injury. Can you tell me one aspect of yourself that has changed which causes you the most distress and holds you back in everyday living?’’   *Main area of difficulty. MEMORY*
1. Emergent awareness: ‘‘Can you tell me how you know that you experience (main difficulty); that is, what do you notice about yourself?’’   *Prompt*: ‘‘What else might you notice?’’; ‘‘So far you’ve told me ...., is there anything else?’’
2. *Anticipatory awareness*: ‘‘When are you most likely to experience (main difficulty), or, in which situations does it mainly occur?’’   *Prompt*: ‘‘In what other situations would you expect more or greater (main difficulty)?’’; ‘‘So far you’ve told me ....., can you think of anything else?’’
3. *Motivation to change*:* ‘‘How motivated are you to learn some different strategies to help overcome (main difficulty)?’’   0 1 2 3 4 5 6 7 8 9 10 ‘‘Not at all’’ ‘‘Very motivated’’

4. *Strategy awareness*: ‘‘Have you thought of any strategies that you could use to help cope with your (main difficulty)?’’ and ‘‘What are they?’’ *Prompt*: ‘‘What else could you try that might help?’’; ‘‘So far you’ve told me ...., can you think of any other strategies?’’
5. *Strategy use*: ‘‘What strategies are you currently using to cope with your (main difficulty)?’’ *Prompt*: ‘‘Can you think of anything else that you are currently using or have tried recently?’’; ‘‘So far you have said ...., are there any other strategies you are using?’’
6. *Strategy effectiveness*: ‘‘How well do the strategies that you are using for (main difficulty) work for you?’’ Prompt: ‘‘How do you know that they are helpful/unhelpful?’’; ‘‘Would you notice any difference if you stopped using the strategies?’’

APPENDIX C

SELF-AWARENESS OF DEFICITS INTERVIEW

1. Self-awareness of deficits

- *Are you any different because of your disability? In what way? Do you feel that anything about you or your abilities has changed (are different)?* ______________________________
____
____
____

- *Do people who know you well notice that anything is different about you as a result of having a disability? What might they notice?* ______________________________
____
____
____

- *What do you see as your problems, if any, resulting from your disability? What is the main thing you need to work on/would like to get better?* ______________________________
____
____
____
____

Prompts

Physical abilities (e.g. movement of arms and legs, balance, vision, endurance)?
Memory/confusion?
Concentration?
Problem-solving, decision-making, organizing and planning things?
Controlling behavior?
Communication?
Getting along with other people?
Has your personality changed?
Are there any other problems that I haven’t mentioned?

2. Self-awareness of functional implications of deficits

- *Does your disability have any effect on your everyday life? In what way?* ______________

Prompts
Ability to live independently?
Managing finances?
Look after family/manage home?
Driving?
Work/study?
Leisure/social life
Are there any other areas of life which you feel have changed/may change?

3. Ability to set realistic goals

- *What do you hope to achieve in the next 6 months? Do you have any goals? What are they?* ______________

- *In 6 months time, what do you think you will be doing? Where do you think you will be?* _

- *Do you think your disability will still be having an affect on your life in 6 months time?*
    - *If yes: how?* ______________
    - *If no: are you sure?* ______________

APPENDIX D

EVERYDAY MEMORY QUESTIONNAIRE – REVISED

Item No.	Item	Once or less in the last month 1	More than once a month, but less than once a week 2	About once a week 3	More than once a week or less than once a day 4	Once or more in a day 5
1.	Forgotten where you have put things					
2.	Failed to recognize places you are told you have often been before					
3.	Find television shows difficult to follow					
4.	Forgotten a change in your daily routine					
5.	Had to go back to check whether you had done something					
6.	Forgotten when something happened					
7.	Forgotten to take things with you					
8.	Forgotten you were told something and had to be reminded					
9.	Started to read something without realizing you had read it before					
10.	Let yourself ramble on about unimportant or irrelevant things					

11.	Failed to recognize, by sight, close friends or relatives					
12.	Had difficulty picking up a new skill					
13.	Found that a word is ‘on the tip of you r tongue’					
14.	Forgotten to do things you said you would do or planned to do.					
15.	Forgotten important details of what you did the day before					
16.	Forgotten what you have just said					
17.	Been unable to follow the thread of a story					
18.	Forgotten to tell somebody something important					
19.	Forgotten important details about yourself					
20.	Got the details of what somebody has told you mixed up					
21.	Told someone a story or joke you have told them already					
22.	Forgotten details of things you do regularly					
23.	Found the faces of famous people look unfamiliar					
24.	Forgotten where things are normally kept					
25a	Got lost where you have OFTEN been before					
25b.	Got lost where you have been only ONCE or TWICE					
26.	Done the same routine twice by mistake					
27.	Repeated to someone what you have just told them					

APPENDIX E

PROSPECTIVE AND RETROSPECTIVE MEMORY QUESTIONNAIRE, WITH DOMAINS

#	Item	Very Often 5	4	3	2	Never 1
1	Do you decide to do something in a few minutes time and then forget to do it					
2	Do you fail to recognize a place you have visited before?					
3	Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?					
4	Do you forget something that you were told a few minutes before?					
5	Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?					
6	Do you fail to recognize a character in a radio or television show from scene to scene?					
7	Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?					
8	Do you fail to recall things that have happened to you in the last few days?					
9	Do you repeat the same story to the same person on different occasion?					
10	Do you intend to take something with you before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?					
11	Do you mislay something that you just put down, like a magazine or glasses?					
12	Do you fail to mention or give something to a visitor that you were asked to pass on?					
13	Do you look at something without realizing you have seen it moments before?					
14	If you have tried to contact a friend or relative who was out, would you forget to try again later?					
15	Do you forget what you watched on television the previous day?					
16	Do you forget to tell someone something you had meant to mention a few minutes ago?					

Prospective and Retrospective Memory Questionnaire – Domains

Item No.	Item	Prospective vs. Retrospective	Short- vs. Long- term	Self-cued vs. Environment cued
1	Do you decide to do something in a few minutes time and then forget to do it	Prospective	Short-term	Self-cued
2	Do you fail to recognize a place you have visited before?	Retrospective	Long-term	Envir. cued
3	Do you fail to do something you were supposed to do a few minutes later even though it's there in front of you, like take a pill or turn off the kettle?	Prospective	Short-term	Envir. Cued
4	Do you forget something that you were told a few minutes before?	Retrospective	Short-term	Self-cued
5	Do you forget appointments if you are not prompted by someone else or by a reminder such as a calendar or diary?	Prospective	Long-term	Self-cued
6	Do you fail to recognize a character in a radio or television show from scene to scene?	Retrospective	Short-term	Envir. Cued
7	Do you forget to buy something you planned to buy, like a birthday card, even when you see the shop?	Prospective	Long-term	Envir. Cued
8	Do you fail to recall things that have happened to you in the last few days?	Retrospective	Long-term	Self-cued
9	Do you repeat the same story to the same person on different occasion?	Retrospective	Long-term	Envir. Cued
10	Do you intend to take something with you before leaving a room or going out, but minutes later leave it behind, even though it's there in front of you?	Prospective	Short-term	Envir. Cued
11	Do you mislay something that you just put down, like a magazine or glasses?	Retrospective	Short-term	Self-cued
12	Do you fail to mention or give something to a visitor that you were asked to pass on?	Prospective	Long-term	Envir. Cued
13	Do you look at something without realizing you have seen it moments before?	Retrospective	Short-term	Envir. Cued
14	If you have tried to contact a friend or relative who was out, would you forget to try again later?	Prospective	Long-term	Self-cued
15	Do you forget what you watched on television the previous day?	Retrospective	Long-term	Self-cued
16	Do you forget to tell someone something you had meant to mention a few minutes ago?	Prospective	Short-term	Self-cued

APPENDIX F

WEEKLY SESSION FORM

Participant ID: _______________ Clinician Initials: ___________ Date: _____________

Module ______ Session: _________ Start Time: _________ Stop Time: _________

1. Did they show up on time?
   - ☐ No
   - ☐ Yes

   Comments:

2. Did you have to remind them of their memory meeting?
   - ☐ No
   - ☐ Yes

   Comments:

3. Did they remember to bring their workbook?
   - ☐ No
   - ☐ Yes

   Comments:

4. Did they complete every HW assignment?
   - ☐ No
   - ☐ Yes

   Comments: (How many did they complete?)

5. Was their homework completed accurately?
   - ☐ No
   - ☐ Yes

   Comments:

6. Did they follow directions (i.e. did they complete one HW assignment per day)?
   - ☐ No
   - ☐ Yes

   Comments:

7. Was the participant engaged during the session?
   - ☐ No
   - ☐ Yes

   Comments:

8. Were they experiencing any distress (i.e. HGAC disciplinary, etc)?
   - ☐ No
   - ☐ Yes

   Comments:

9. If client made errors on their homework assignments, please describe the errors that they made: ____
   ____
   ____
   ____
   ____

APPENDIX G

TELEHEALTH USABILITY QUESTIONNAIRE – USABILITY

		N/A		1	2	3	4	5	6	7	
1.	Telehealth improves my access to healthcare services.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
2.	Telehealth saves me time traveling to a hospital or specialist clinic.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
3.	Telehealth provides for my healthcare need.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
4.	It was simple to use this system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
5.	It was easy to learn to use the system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
6.	I believe I could become productive quickly using this system	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
7.	The way I interact with this system is pleasant.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
8.	I like using the system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
9.	The system is simple and easy to understand.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
10.	This system is able to do everything I would want it to be able to do.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
11.	I can easily talk to the clinician using the telehealth system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
12.	I can hear the clinician clearly using the telehealth system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
13.	I felt I was able to express myself effectively.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
14.	Using the telehealth system, I can see the clinician as well as if we met in person.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE

15.	I think the visits provided over the telehealth system are the same as in-person visits.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
16.	Whenever I made a mistake using the system, I could recover easily and quickly.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
[redacted]											
19.	Telehealth is an acceptable way to receive healthcare services.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
20.	I would use telehealth services again.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
21.	Overall, I am satisfied with this telehealth system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE

Please provide comments about the telehealth system:

………
………
………
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………

SCORING

$$\textit{Overall score} = \frac{\text{Total score}}{21}$$

Construct scores

$$\text{Usefulness} = \frac{\text{item 1} + \text{item 2} + \text{item 3}}{3}$$

Constructs

- Usefulness – 3 items
- Ease of use – 6 items
- Effectiveness - 5 items
- Reliability – 3 items
- Satisfaction – 4 items

Specific items per construct

Usefulness

- Telehealth improves my access to healthcare services
- Telehealth saves me time traveling to a hospital or specialist clinic
- Telehealth provides for my healthcare needs

Ease of use

- It was simple to use this system
- It was easy to learn to use the system
- I believe I could become productive quickly using this system
- The way I interact with this system is pleasant
- I like using the system
- The system is simple to understand

Effectiveness

- This system is able to do everything I would want it to be able to do
- I can easily talk to the clinician using the telehealth system
- I can hear the clinician clearly using the telehealth system
- I felt I was able to express myself effectively
- Using the telehealth system, I can see the clinician as well as if we met in person

Reliability

- I think the visits provided over the telehealth system are the same as in-person
- Whenever I made a mistake using the system, I could recover easily and quickly
- The system gave error messages that clearly told me how to fix problems

Satisfaction

- I feel comfortable communicating with the clinician using the telehealth system
- Telehealth is an acceptable way to receive healthcare services
- I would use telehealth services again
- Overall, I am satisfied with this telehealth system

APPENDIX H

SUMMATIVE USABILITY QUESTIONNAIRE

To be answered for each homework activity

We understand that there are inherent differences between the electronic activities delivered through the tablet and the original paper based activities. The purpose of this study is to identify differences in the activities that may contribute to an external variance that would be the reason for the differences between the telerehabilitation group and the face-to-face group.

Please rate the degree to which the electronic activities differ to the paper based activities for the following factors:

	Min Diff						Max Diff
	1	2	3	4	5	6	7
Homework Activity							
Timing							
Instruction Delivery							
Alter or change the demands of the task							
Other:							

1. **In what ways is the electronic activity clinically different from paper homework activity?**

To be completed after review of all Post-Memory Training Administration

1. **In what ways is the overall presentation of the electronic activity clinically different from paper homework activity?**

2. **Please identify any factors that may confound attributing differences to the treatment (tablet based homework activities) as opposed to the condition (paper based homework activities)?**

APPENDIX I

SATISFACTION WITH TELEREHABILITATION

1. **I felt comfortable completing the homework activity using the tablet computer.**

Strongly Agree 1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

1. **I felt comfortable meeting with the memory therapist using the computer.**

Strongly Agree 1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

2. **The quality and clarity of the video (picture) was acceptable.**

Strongly Agree 1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

3. **The quality and clarity of the audio (sound) was acceptable.**

Strongly Agree 1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

4. **There were things I was unable to do because of the computer system that I would have been able to do using a paper and pencil.**

Strongly Agree	1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

5. **If I had to have rehabilitation services in the future, I would be willing to do them over the computer.**

Strongly Agree	1	2	3	4	5	6	7	*Strongly Disagree*

Comments:

1. **What changes would make the system more usable?**

2. **What additions would make the system more usable?**

APPENDIX J

TELEHEALTH USABILITY QUESTIONNAIRE – CLINICAL

		N/A		1	2	3	4	5	6	7	
1.	Telehealth improves my access to healthcare services.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
2.	Telehealth saves me time traveling to a hospital or specialist clinic.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
3.	Telehealth provides for my healthcare need.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
4.	It was simple to use this system. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
5.	It was easy to learn to use the system. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
6.	I believe I could become productive quickly using this system (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
7.	The way I interact with this system is pleasant. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
8.	I like using the system. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
9.	The system is simple and easy to understand. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
10.	This system is able to do everything I would want it to be able to do. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
11.	I can easily talk to the clinician using the telehealth system. (VISYTER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
12.	I can hear the clinician clearly using the telehealth system. (VISTYER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
13.	I felt I was able to express myself effectively. (VISTYER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
14.	Using the telehealth system, I can see the clinician as well as if we met in person. (VISTYER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
15.	I think the visits provided over the telehealth system are the same as in-person visits. (VISTYER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE

16.	Whenever I made a mistake using the system, I could recover easily and quickly. (Tablet PC)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
[redacted]											
18.	I feel comfortable communicating with the clinician using the telehealth system. (VISYTER)	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
19.	Telehealth is an acceptable way to receive healthcare services.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
20.	I would use telehealth services again.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE
21.	Overall, I am satisfied with this telehealth system.	☐	DISAGREE	☐	☐	☐	☐	☐	☐	☐	AGREE

Please provide comments about the telehealth system:

……………………………………………………………………………………………………
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APPENDIX K

PARTICIPATION ASSESSMENT WITH RECOMBINED TOOLS-

OBJECTIVE/SATISFACTION

<u>PART: OBJECTIVE ITEMS</u>

I am going to begin this interview with questions about your typical activities. So, first . . .

	Categories for O1 through O6		0-5	7/9
	READ 0 None 1 1-4 hours 2 5-9 hours 3 10-19 hours 4 20-34 hours 5 35 or more hours	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O1	In a typical <u>week</u>, how many <u>hours</u> do you spend in active homemaking, including cleaning, cooking and raising children?			
O2	In a typical week, how many hours do you spend in home maintenance activities, such as home repairs, home improvements and gardening?			
O3	In a typical week, how many hours do you spend in school working toward a degree or in an accredited technical training program, including hours in class and studying?			
O4	In a typical week, how many hours do you spend working for money, whether in a job or self-employed?			
O5	In a typical week, how many hours do you ride in trains, buses, taxis and other public transportation? This includes public transportation for people with disabilities?			
O6	In a typical week, how many hours do you drive or ride in a car? This includes all types of private transportation?			

So far, I've asked questions about the amount of time you engage in activities. Now, I'll ask you about how often you do things. So…

	Categories for O7 through O10		0-5	7/9
	READ: 0 None 1 1-4 times 2 5-9 times 3 10-19 times 4 20-34 times 5 35 or more times	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O7	In a typical week, how many times do you socialize with friends, in person or by phone? Please do not include socializing with family members?			
O8	In a typical week, how many times do you socialize with family and relatives, in person or by phone?			
O9	In a typical week, how many times do you give emotional support to other people, that is, listen to their problems or help them with their troubles?			
O10	In a typical week, how many times do you use the Internet for communication, such as for e-mail, visiting chat rooms or instant messaging?			

	Sum of 0-5 column		
	Count of 7/9 entries		

	Categories for O11		0-5	7/9
	READ: 0 None 1 1-2 days 2 3-4 days 3 5-6 days 4 7 days	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O11	In a typical week, how many days do you get out of your house and go somewhere? It could be anywhere – it doesn't have to be anyplace "special"?			

IF FROM PREVIOUS ANSWERS THE ANSWER TO THE FOLLOWING QUESTION IS CLEAR, RECORD THE ANSWER AND SKIP TO O13. IF THERE IS **ANY** DOUBT, ASK THE QUESTION.

	Categories for O12		0-5	7/9
	READ: 0 I rarely leave my bed 1 I rarely leave my room - but I do get out of bed 2 I rarely leave my house - but I do get out of my room 3 I rarely leave my block or neighborhood - but I do get out of the house 4 I travel beyond my block or neighborhood	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O12	Now, I'd like you to think about a typical month . . . What best describes how you spend your days in a typical month?			

Now I have questions on how often you do various things in a typical month.

	Categories for O13 through O15		0-5	7/9
	READ: 0 None 1 1-4 times 2 5-9 times 3 10-19 times 4 20-34 times 5 35 or more times	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O13	In a typical month, how many times do you eat in a restaurant?			
O14	In a typical month, how many times do you go shopping? Include grocery shopping, as well as shopping for household necessities, or just for fun?			
O15	In a typical month, how many times do you engage in sports or exercise outside your home? Include activities like running, bowling, going to the gym, swimming, walking for exercise and the like			

	Sum of 0-5 column		
	Count of 7/9 entries		

I have more questions on how a typical month looks like, but please note that the answer categories are different.

	Categories for O16 through O20		0-5	7/9
	READ: 0 None 1 One time 2 Two times 3 Three times 4 Four times 5 Five or more times	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O16	In a typical month, how many times do you do volunteer work?			
O17	In a typical month, how many times do you go to the movies?			
O18	In a typical month, how many times do you attend sports events in person, as a spectator?			
O19	In a typical month, how many times do you attend religious or spiritual services? Include places like churches, temples and mosques?			
O20	In a typical month, how many times do you participate in a club or organization, such as the PTA, a choir, sorority, hobby group, neighborhood organization, brain injury or other support group?			

	Categories for O21 through O24		0-5	7/9
	READ: 0 No 5 Yes	**DO NOT READ:** 7 DON'T KNOW/NOT SURE 9 REFUSED		
O21	Now, I'd like you to think about the last three months. In that time, have you taken adult education classes, GED classes, continuing education, special courses, or used other opportunities for learning, for instance, seminars or conferences?			
O22	Switching, now, to a somewhat different kind of question . . . Do you live with your spouse or significant other (IF Yes, SKIP TO QUESTION O24)			
O23	Are you currently involved in an ongoing intimate, that is, romantic or sexual, relationship?			
O24	[OMIT THE FIRST PART IF THE PERSON DOES NOT HAVE A SPOUSE, AND DOES NOT HAVE A S.O. AND IS NOT IN AN INTIMATE RELATIONSHIP] [Not including your spouse or significant other], do you have a close friend in whom you confide?			

	Sum of 0-5 column		
	Count of 7/9 entries		

Total score calculation:	Sum of 0-5 column	Count of 7/9 column	Total score= A / (23 – B)=
Page 1			______ / (23 - ______) = ______ / ______ = __________
Page 2			
Page 3	========== +	========== +	
Total	A	B	

PART: SUBJECTIVE ITEMS

IMPORTANCE: So far, we have talked about your typical activities. Now, I'd like to try to get a sense of which of your activities and relationships are important to you. I'm going to read a list of areas of activity and then ask you how important each is to you.

I'm sure some of these areas are very important, while others are less important. As I read the list I would like you to tell me if an area is of high, medium or low importance to you at this time.

(IN THE IMPORTANCE COLUMN, CIRCLE HI, MED, OR LOW.) IF THE PERSON RATES AN AREA AS BEING OF LOW IMPORTANCE, ASK THE FOLLOWING: Did you rate this area as of low importance only because it is not part of your life right now, while in reality it **is** important to you and you would like to **have** it in your life? IF YES, Would you want to change your mind and call it of medium or high importance? IF YOU COMPLETE A HARD-COPY FORM, MAKE SURE YOU MAKE CLEAR WHICH OF THE ITEMS CIRCLED IS THE FINAL ANSWER.

	IMPORTANCE READ: 0 Low importance 1 Medium importance 2 High importance **SATISFACTION READ:** 0 Totally dissatisfied **…** 10 Completely happy **DO NOT READ:** 77 DON'T KNOW/ NOT SURE 99 REFUSED	**IMPORTANCE**		**SATISFACTION**		
	Area of Activity	0-2	77/99	0-10	77/99	products
S1	Going to school and other opportunities for you to learn. Do not include school for your children					
S2	Paid and unpaid work, in other words, having a job or volunteering					
S3	Having and raising children					
S4	Housekeeping and other activities to keep your home in good order					
S5	A relationship with a spouse or significant other					
S6	Relationships with family and relatives. This includes relationships with your adult children, if you have any.					
S7	Relationships with friends and acquaintances					
S8	Public and private transportation					
S9	Participation in religious services and functions					
S10	Activities in other organizations, or other parts of your community					
S11	Recreation and leisure, whether at home or elsewhere - the activities you do "for fun"				=== +	=== +
	Sum of satisfaction scores / sum of weighted satisfaction scores (SKIP 77 and 99)					
	Mean of satisfaction scores / mean of weighted satisfaction scores (DIVIDE BY NUMBER OF NON-77/99 ENTRIES)					
S12						
S13						

APPENDIX L

VISYTER SPECIFICATIONS

1. **Computer Requirements**

   For two-way video conferencing – Minimum configuration

   a. Pentium IV 2.0 GHz dual processor

   b. 1 GB of RAM

   c. NVIDIA GeForce4 graphics card

2. **Network Requirements**

   a. Host computer of a conference must use a static IP address.

   b. Non-hosting computers can use dynamic (DHCP) IP addresses.

   c. All computers should use a high-speed connection that supports multicasting or have access to a reflector service if within unicast network.

   d. Minimum Requirements

      i. High-speed internet service provider that has a

      ii. Download speed of 1 Mbps and an

      iii. Upload speed of 384 Kbps.

3. **Audio/Video Requirements**

   a. Microphone and Speaker Minimum Requirements

      i. Plantronics Audio PC headset or Logitech Notebook headset.

      ii. For group conferencing –

         1. USB speakerphone
         2. echo-canceling microphone

Figure 21. Clear One Chat 70 USB Microphone

b. Camera Minimum Requirements

i. Wireless or USB-connected camera

1. At least 3 MP of resolution is required to use VISYTER

Figure 22. Logitech c910 Camera

4. Software Requirements

a. The following software should be installed on the computer:

- Operating System: Microsoft Window XP, Vista, or Server 2003
- Webcam Driver
- Latest audio drivers
- VISYTER installer

APPENDIX M

VISYTER SCREEN SHOTS OF ACTUAL SESSIONS

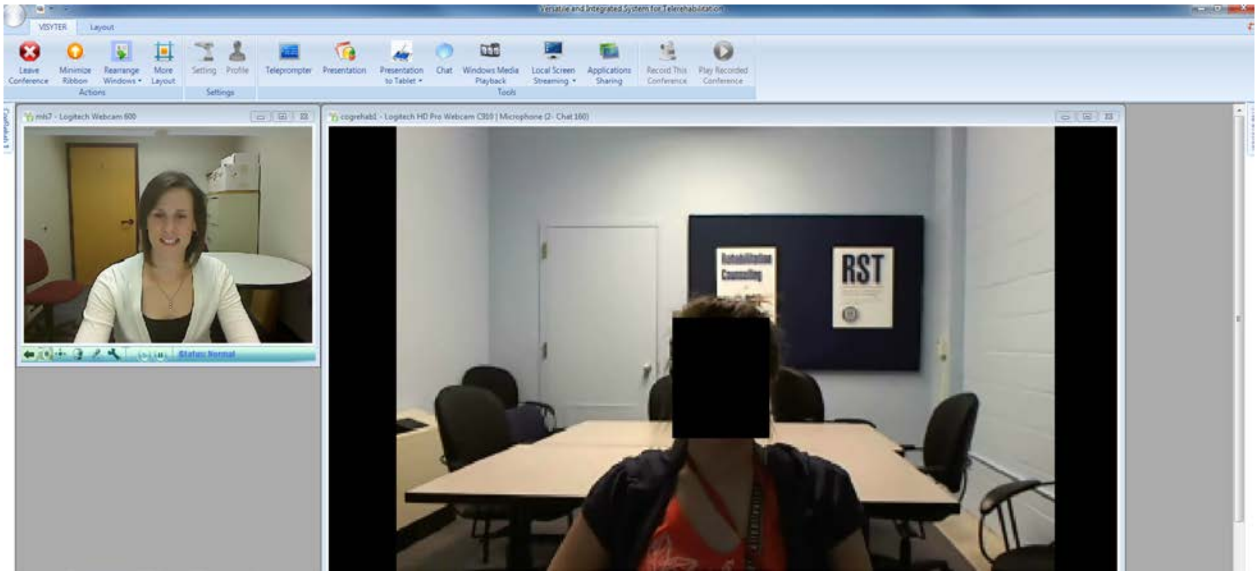

Figure 23. Remote Meeting Between Researcher 1 and Telerehabilitation Subject

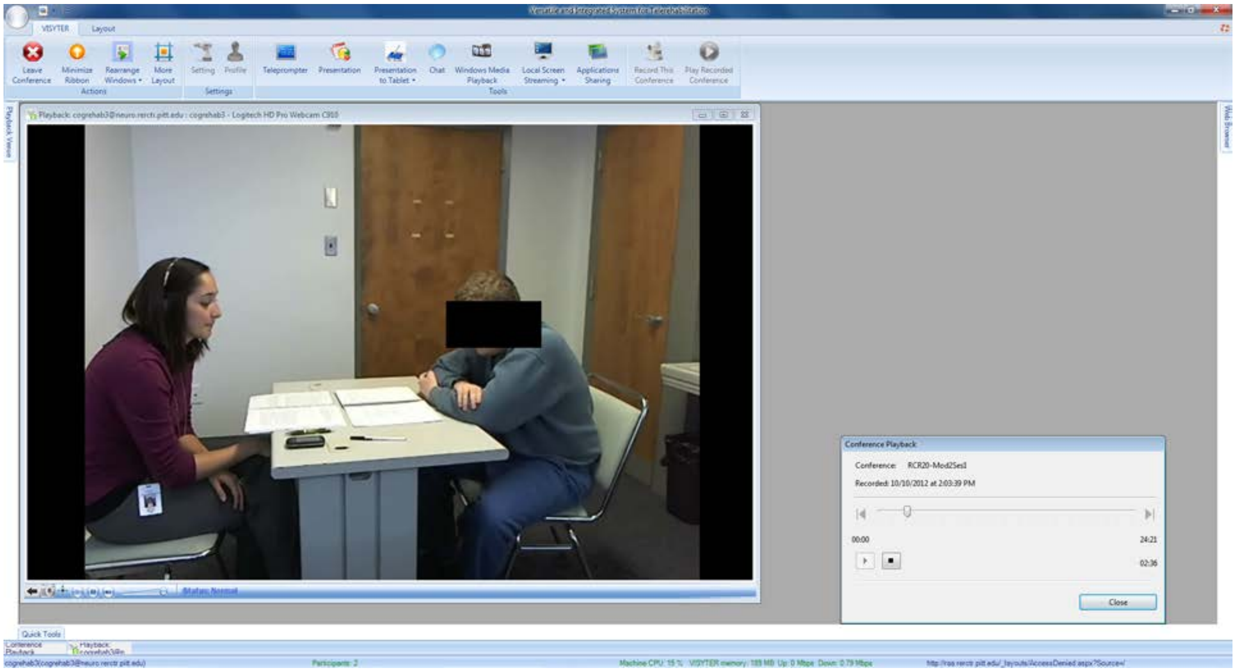

Figure 24. Face-to-Face Meeting between Researcher 3 and Face-to-Face Subject

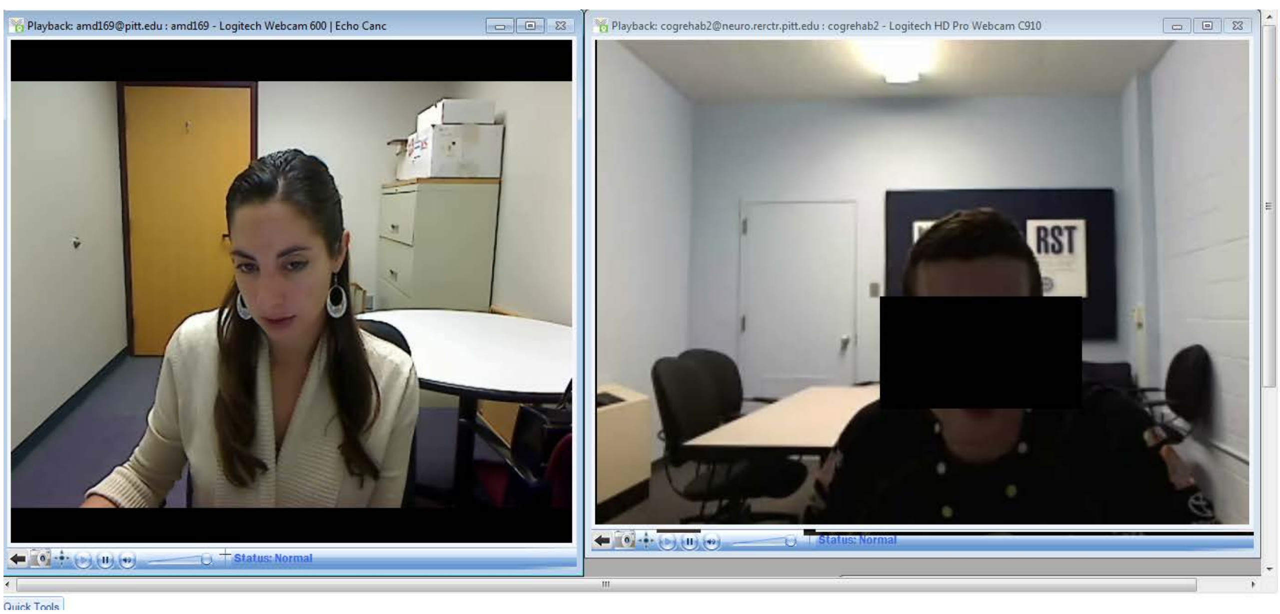

Figure 25. Remote Meeting between Researcher 2 and Telerehabilitation Subject

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