January 2012

The Effects of Cognitive Stimulation and Computerized Memory Training among Older Adults Residing in Indepedent-Living Facilities

Elizabeth M. Hudak
University of South Florida, egagnon@mail.usf.edu

The Effects of Cognitive Stimulation and Computerized Memory Training among Older Adults Residing in Independent-Living Facilities

by

Elizabeth M. Hudak

A dissertation submitted in partial fulfillment
of the requirement for the degree of Doctor of Philosophy
School of Aging Studies
College of Behavioral and Community Sciences
University of South Florida

Major Professor: Jerri D. Edwards, Ph.D.
Ross Andel, Ph.D.
Jennifer J. Lister, Ph.D.
Cathy L. McEvoy, Ph.D.
Christine L. Ruva, Ph.D.

Date of Approval:
July 5, 2012

Keywords: cognitive interventions, short-term memory, long-term memory, adaptive cognitive training, cognition, brain fitness

Table of Contents

List of Tables

List of Figures

Abstract

Background: With age, older adults experience declines in both short- and long-term memory. One way to counter these age-related declines is through memory interventions which include computerized cognitive training and non-computerized cognitive stimulation. This dissertation examined whether a cognitive training program, *Dakim BrainFitness* (Dakim Inc., 2002) and a program of cognitive stimulation, *Mind Your Mind* (Seagull & Seagull, 2007), enhance memory performance among cognitively-intact older adults residing in independent-living retirement communities. Specifically, the following research questions were proposed: (a) How effective is the computerized cognitive training program in improving memory performance relative to the cognitive stimulation program or a no-contact control condition? (b) How effective is the non-computerized cognitive stimulation program, *Mind Your Mind,* at improving memory performance relative to a control condition? and (c) Will memory training gains endure 3-months post-training for those who participate in cognitive training?

Method: Fifty-three older adults were randomized to cognitive training (n = 19), cognitive stimulation (n = 17), or a no-contact control (n = 17) condition. Participants in the cognitive training and cognitive stimulation conditions were

asked to complete five 25-minute sessions per week for a 10-week period. Memory outcome measures included the Auditory Verbal Learning Test (AVLT), the Hopkins Verbal Learning Test (HVLT), and the Wechsler Memory Scale-Third Edition (WMS-III) Family Pictures subtest. Outcome measures were administered at baseline, immediately post-training (or equivalent delay), and again at 3-months post-training.

Results: Multivariate Analysis of Variance indicated no significant differences between the three training conditions on baseline characteristics and memory outcome scores (p = .660). To test hypotheses one and two, memory outcome measures were compared across training conditions and testing occasions. A repeated measures MANOVA indicated a significant group x time interaction, Wilks' Λ =.585, $F(10,92) = 2.83$, $p = .004$, partial $\eta^2 = .235$. Follow-up analyses for each memory outcome measure from baseline to immediately post-training were conducted with training condition as the independent variable. Significant group x time interactions were found between conditions for AVLT delayed recall, $F(2,50) = 3.683$, $p = .032$, partial $\eta^2 = .128$, and the HVLT immediate recall, $F(2,50) = 5.059$, $p = .010$, partial $\eta^2 = .168$. No significant group x time interaction was indicated on the AVLT immediate recall, $F(2,50) = 2.544$, $p = .089$, partial $\eta^2 = .092$. There was a marginally significant group x time interaction on the WMS-III Family Pictures delayed recall $F(2,50) = 2.975$, $p = .060$, partial $\eta^2 = .106$.

Post-hoc comparisons for significant outcome measures were conducted using Fisher's LSD test, while controlling for baseline performance. Results indicated that the cognitive training condition performed significantly better than the cognitive stimulation condition from baseline to immediately post-training on the AVLT delayed recall ($p = .012$), as well as on HVLT immediate recall ($p < .001$). The cognitive training condition also performed significantly better from baseline to immediately post-training as compared to the no-contact control condition ($p = .011$). A significant difference between the cognitive training condition and the no-contact control condition was also found on the WMS-III delayed recall measure ($p = .030$) immediately post-training. No significant differences between any of the conditions were found on either AVLT immediate or WMS-III Family Pictures immediate recall (*p*s > .05). There were no differences between the cognitive stimulation and control conditions across all memory outcomes (*p*s > .05). For hypothesis three, a repeated measures MANOVA indicated no main effect of time within the cognitive training condition for the memory outcome measures, Wilks' $\Lambda = .047$, $F(6,11) = 2.11$, $p = .135$, partial $\eta^2 = .535$.

Discussion: These findings provide evidence that the adaptive computerized cognitive training program, Dakim BrainFitness, significantly improved memory abilities as measured by the AVLT delayed recall, HVLT, and WMS-III Family Pictures delayed recall relative to cognitive stimulation. In contrast, there were no significant improvements for participants in the non-adaptive, non-computerized program of cognitive stimulation relative to controls. These findings coincide with the Model of Adult Cognitive Plasticity that in order to improve cognitive performance, there needs to be a mismatch between the individual's capacities and the demands of the task. Adaptive cognitive training may be more likely to provide a mismatch and produce positive plasticity changes in the brain. Future research pertains to exploring the cognitive benefits that these programs have on other types of cognitive domains.

Chapter One: Introduction

Background

Cognitive interventions are designed to reverse cognitive declines experienced by older adults with aging. More specifically, because one of the biggest complaints among healthy older adults continues to be memory loss (Balota, Dolan, & Duchek, 2000; Floyd & Scogin, 1997; Ronnlund, Nyberg, Bäckman, & Nilson, 2005), many cognitive interventions have focused on the enhancement of memory performance (Ball et al., 2002; Buschkuehl et al., 2008; Carretti, Borella, & De Beni, 2007; Engvig et al., 2010; Mahncke et al., 2006; Rasmusson, Rebok, Bylsma, & Brandt, 1999; Verhaeghen, Marcoen, & Goossens, 1992; Wilson, 2005). This dissertation study examined whether a cognitive training program, *Dakim BrainFitness* (Dakim Inc., 2002) and a program of cognitive stimulation, *Mind Your Mind* (Seagull & Seagull, 2007), were effective at enhancing memory performance among cognitively-intact older adults residing in independent-living retirement communities.

Age-Related Changes in Memory

Memory is comprised of multiple systems that are organized by the type of information being retrieved, and the length of time it is retained (Brickman & Stern, 2009). Each of these systems experience a different degree of vulnerability to the negative effects of aging (Brickman & Stern, 2009).

Short-Term and Working Memory. Short-Term Memory (STM) and Working Memory (WM; Baddeley & Hitch, 1974) are terms that are often used interchangeably even though there is a distinct difference between the two (Old & Naveh-Benjamin, 2008). STM refers to information that is in the conscious awareness for a very brief period of time (Old & Naveh-Benjamin, 2008) whereas WM involves the active maintenance and manipulation of information (Brickman & Stern, 2009; Old & Naveh-Benjamin, 2008; Salthouse, 1994). Episodic STM which pertains to time and space of information (Tulving, 1993), and WM has shown to be negatively affected by aging. However, studies indicate that WM is much more susceptible to age-related changes than STM (Bopp & Verhaeghen, 2005; Brickman & Stern, 2009; Glisky, 2007; McKoon, Ratcliff, & Dell, 1986; Old & Naveh-Benjamin, 2008; Schieber, 2002). As one example, Park and colleagues (2002) compared younger and older adults on visuospatial and verbal tasks of STM (forward digit span and backwards digit span) and WM (computation span and reading span). Performance on both the WM and STM tasks were worse with increasing age, however, age-related difficulties with the WM tasks were larger than that of the STM tasks. It is thought that the performance differences exist because WM requires both processing and storage, whereas STM tasks only require storage (Old & Naveh-Benjamin, 2008; Park, et al., 2002; Salthouse, 1994)

Long-Term Memory. LTM refers to stored information that is no longer in the active state of consciousness, the STM. Typically, such memory is examined over delayed intervals of time (Brickman & Stern, 2009).

Implicit and Explicit Memory. Implicit and explicit LTM vary in their susceptibility to age-related changes (Brickman & Stern, 2009; Drag & Bieliauskas, 2010; Mitchell & Bruss, 2003; Old & Naveh-Benjamin, 2008; Park & Shaw, 1992). Explicit memory is the intentional retrieval of past experiences, whereas implicit memory is the unintentional retrieval of past experiences that influences an individual's behavior (Drag & Bieliauskas, 2010; Old & Naveh-Benjamin, 2008; Roediger, 1990; Schacter, 1987). Research indicates that explicit memory abilities, but not implicit, declines with age (Drag & Bieliauskas, 2010; Mitchell & Bruss, 2003; Park & Shaw, 1992). For example, Mitchell and Bruss (2003) examined age differences in implicit (as measured by word-fragment completion, word-stem completion, category exemplar generation, picture-fragment identification, and picture naming) and explicit (category cued recall, task memory, and WAIS-III Vocabulary Memory) memory of young, middle-aged, and older adults. Significant differences between age conditions were observed only for explicit memory tasks, with older adults performing worse than younger adults.

In addition to age differences in memory observed in cross-sectional studies, longitudinal analyses indicate memory changes with age. A study by Zelinski and Burnight (1997) examined longitudinal changes in verbal explicit memory among a sample of older adults between the ages of 55-81 over a 16-year period. At two time points 16-years apart, participants were administered three measures of explicit memory that consisted of the following: (1) immediate recall of a 20-word list of concrete high frequency nouns that were studied for 3 minutes, (2) immediate recall of an essay that was read and heard by the participants simultaneously and (3) 20-minute delayed recognition of the words from a list including the original items and 20 foils. Results indicated longitudinal decline over the 16 years among adults over the age of 55 in text and list recall, but not recognition. Other longitudinal studies such as the Victoria Longitudinal Study (McDonald-Miszczak, Hertzog, & Hultsch, 1995) and the Iowa 65+ Rural Health Study (Colsher & Wallace, 1991) have similar findings of explicit memory declines across 6-years.

Episodic and Semantic Memory. Within explicit LTM, memory is further categorized as episodic or semantic LTM. Age does not impact episodic and semantic LTM equally (Brickman & Stern, 2009).

In the STM system, episodic memory pertains to experiences that are within the conscious awareness (Old & Naveh-Benjamin, 2008). In LTM, episodic memory pertains to the conscious recollection of personally experienced events that focuses on the ‘where’, ‘what’, and ‘when’ of stored information (Brickman & Stern, 2009). In contrast, semantic memory is the storage of factual knowledge that is not related to any specific time or place (Drag & Bieliauskas, 2010; Old & Naveh-Benjamin, 2008; Tulving, 1983; Weiten, 2004). The impact of age upon episodic and semantic LTM has been demonstrated in many studies (Balota, Duchek, & Paullin, 1989; Head, Rodrigue, Kennedy, & Raz, 2008; Nyberg, Bäckman, Erngrund, Olofsson, & Nilsson, 1996; Spaniol, Madden, & Voss, 2006; Zacks, Hasher, & Li, 2000). A study by Spaniol, Madden, and Voss (2006) included younger and older adults who were asked to judge the pleasantness of a series of words; half of which described living things. After being presented with a list the words and given 1-minute for retention, each participant completed an episodic or semantic memory test. Participants who completed the episodic memory test responded as quickly as possible to whether a certain word was from the study list. Participants who completed the semantic memory test were asked to respond as quickly as possible as to whether a given word described a living or nonliving thing. Results from this study showed that younger adults perform better than older adults on tasks of episodic memory, but no age differences were evident for tasks of semantic memory.

Studies indicate that the observed age differences in episodic LTM are directly related to encoding and retrieval processes (Brickman & Stern, 2009). For example, Craik and McDowd (1987) found large age-related deficits in the ability to recall a target word following presentation, but no significant age differences in the ability to make recognition-type responses to target words. This indicates that age-related difficulties in episodic memory are attributable to encoding and retrieval tasks that require a higher amount of processing such as free recall (Brickman & Stern, 2009; Craik & McDowd, 1987; Drag & Bieliauskas, 2010; Old & Naveh-Benjamin, 2008).

To summarize, semantic and implicit memory remain relatively stable throughout the lifespan (Old & Naveh-Benjamin, 2008; Stine-Morrow & Miller, 1999), but declines in STM, WM, explicit memory, and episodic memory (both short- and long-term) are evident. One way to counter age-related declines in these memory abilities is through memory training (e.g., Ball, et al., 2002; Bond, Wolf-Wilets, Fiedler, & Burr, 2000; Buschkuehl, et al., 2008; Carretti, et al., 2007; Gunther, Schafer, Holzner, & Kemmler, 2003). To understand how cognitive interventions are able to successfully improve memory abilities, researchers proposed the Model of Adult Cognitive Plasticity.

Theoretical Support

Model of Adult Cognitive Plasticity. Plasticity represents the flexibility of the brain to optimize performance in reaction to environmental demands (Lövdén, Bäckman, Lindenberger, Schaefer, & Schmiedek, 2010). When there is a decrease in brain demands, negative plasticity (cognitive decline) occurs, while an increase in brain demands results in positive plasticity (cognitive improvement). Whether positive or negative, the brain is capable of reorganizing the patterns and systems of connections between neurons and synapses to adjust the amount of demand received (Stiles, 2000).

The Model of Adult Cognitive Plasticity (Lövdén, et al., 2010) claims that cognitive interventions are effective when there is a mismatch between the individual's cognitive capacities and the demands of the task (Lövdén, et al., 2010). If the task is effortless, the brain can respond easily with no mismatch between the brain and environmental demand. This causes no changes within the brain. In contrast, if a task is cognitively challenging, it will make the brain work harder than its capacity, providing stimulation within the brain. The stimulation of neurons and synapses in the brain results in significantly improved memory performance (Hertzog, Kramer, Wilson, & Lindenberger, 2009; Verhaeghen, et al., 1992).

Engagement Hypothesis. The engagement hypothesis states that older adults who engage in cognitively-stimulating activities will experience less cognitive decline over time, and a reduced chances of developing dementia compared to inactive individuals (Fratiglioni, Paillard-Borg, & Winblad, 2004). According to this perspective, individuals who participate in either cognitive training or cognitive stimulation should experience a slower rate of cognitive decline.

Cognitive Interventions to Enhance Memory

To enhance the memory abilities negatively impacted with age, a variety of training techniques and formats are used as interventions. Techniques include general cognitive stimulation and computerized cognitive training. Within each technique, the format varies in the type of strategy used (e.g., mnemonic or strategic) (See Papp, Walsh, & Snyder, 2009 for review). As a result, it is difficult to conclude which type of training is most or least effective at enhancing memory abilities among the older adult population. However, determining the effectiveness of different memory training programs to improve the memory functioning of older adults can help researchers identify, and older adults utilize, effective memory training programs.

Computerized memory training. Many studies have used computer-based training as a way to enhance memory function among older adults (e.g., Bond, et al., 2000; Buschkuehl, et al., 2008; Gunther, et al., 2003; Larrabee & Crook, 1989; Mahncke, et al., 2006; Rasmusson, et al., 1999). For example, a study by Buschkuehl and colleagues (2008) examined the efficacy of 12 weeks of computerized training in which participants had two training sessions per week, each lasting approximately 45 minutes. Participants in the experimental condition trained on WM (sequence repetition and object identification) and reaction time (object identification) tasks. The active control condition included physical activity with the use of an exercise bicycle for the same amount of time as the experimental group. Increased memory performance as indicated by visual WM and visual episodic STM among the experimental group, compared to the active control group, immediately after memory training completion was seen. However, no group differences were found one year after memory training was completed (Buschkuehl, et al., 2008). Consistent with other studies (Ball, et al., 2002; Bond, et al., 2000; Gunther, et al., 2003; Li et al., 2008), episodic STM and WM abilities were significantly improved through memory training.

Another type of computerized memory training program used to improve STM in a study conducted by Mahncke et al. (2006). In this study, participants were randomly assigned to the experimental computer-based training, the active computer-based control, or the no-contact control group. Computerized training for the experimental group involved the Brain Fitness software developed by Posit Science. This cognitive training program consists of six auditory cognitive exercises designed to enhance cognitive performance. These six exercises (High or Low, Tell Us Apart, Match It!, Sound Replay, Listen and Do, and Story Teller) adjust in difficulty depending on the users performance. Training lasted for 60 minutes a day, 5 days a week, for 8-10 weeks at home. The active computer-based control group viewed DVD-based audiovisual educational material on a computer with the same training schedule as the experimental group (60 minutes a day, 5 days a week, for an 8-10 week period). The no-contact control group did not participate in study-related activities beyond consent and the three testing visits (pre-, post-, and follow-up). Results from this study show that computerized training significantly improved auditory STM performance up to 25%, which remained enhanced three months later (Mahncke, et al., 2006). These results are consistent with other computerized memory training studies that found significant improvements in STM performance among older adults (e.g., Larrabee & Crook, 1989; Mahncke, et al., 2006; Rebok, Rasmusson, & Brandt, 1996).

Advantages and disadvantages. Computerized cognitive training techniques have many advantages over non-computerized training. Computerized techniques tend to be cost effective, self-administered, flexible with training times, and easy to distribute (Rebok, Carlson, & Langbaum, 2007). During training, most computerized programs can measure change, provide immediate feedback and scoring, and give supportive and motivational messages to enhance learning (Gunther, et al., 2003). In addition, computerized training can adapt exercises to each participant's level of performance throughout training. According to some researchers (Lövdén, et al., 2010; Valenzuela & Sachdev, 2009), this keeps training at an optimal level of challenge; allowing the user to get the most benefit from the system. Most importantly, research has demonstrated that computerized memory training is an effective tool for enhancing various memory abilities including WM, STM, and episodic LTM among older adults (Bond, et al., 2000; Gunther, et al., 2003; Mahncke, et al., 2006; Rebok, et al., 2007).

There are also certain disadvantages associated with computerized memory training. Besides participants needing access to computers, it is also likely that some older adults will not know how to operate one (Rebok, et al., 2007). However, this is becoming less of an issue as baby boomers age and the use of computers among the older adult population grows (Rebok, et al., 2007). Although some older adults might not know how to operate computers, research shows that participants are able to use computerized training programs independently and successfully after given basic instruction (Rebok, et al., 1996). Companies promoting brain fitness products, such as Dakim, Inc., are making it easier for older adults to train on computers by incorporating touch screens (no mouse or keyboard), using information that is more relevant to their generation, and requiring no previous knowledge of a computer in order to operate.

Dakim BrainFitness. Moving into the next generation of cognitive training, a computerized cognitive training program called Dakim BrainFitness was developed in 2002 for active seniors and for those who may have mild cognitive issues. The program has many features including touchscreen monitors so users do not need to utilize a mouse of keyboard, feedback on performance, cohort-relevant information, and daily updated games and information, making this system appealing to the older adult population. In fact, according to Dakim Inc. (2002), BrainFitness is the most widely used brain fitness product among senior living communities.

The Dakim BrainFitness system has a total of 50 games designed to stimulate six cognitive domains: STM, LTM, language, computation, visuospatial orientation, and critical thinking. While many games are designed to improve more than one cognitive domain, 12 Dakim BrainFitness games are designed to improve STM and seven games are designed to improve LTM. The memory games incorporate instructions on memory techniques including association, visualization, and the story method. See the Method section for detailed information about these exercises.

In order to accommodate the degree of variance in cognitive functioning among older adults, this program implements five levels of challenge. Level 1 is designed for older adults who have no cognitive decline, levels 2-3 are for those with typical age related decline, and levels 4-5 are for those with mild to moderate decline or dementia.

The Dakim BrainFitness cognitive training program is adaptive and adjusts the level of difficulty within each cognitive domain. For example, a user mastering a calculation question will see an increase in the difficulty of the material. This process ensures that the participant is maintaining an optimal level of challenge (Valenzuela & Sachdev, 2009). Maintaining this level of challenge may ensure that the user is getting the most benefit from the system.

Although this program claims to be the most widely used brain fitness program among senior-living communities, only one study has been conducted to examine the efficacy of the Dakim BrainFitness program on memory abilities. This study, conducted by Miller and colleagues (Miller et al., 2010), examined whether the use of the Dakim BrainFitness program improved immediate memory (as measured by the Total Buschke-Fuld, Rey-Osterrieth, and Total Learning Verbal Paired Associates I) and delayed memory (as measured by the Total Buschke-Fuld, Rey-Osterrieth and delayed recall Verbal Paired Associates II) among 41 cognitively-healthy older adults residing in independent-living facilities. Participants were randomized to either the Dakim BrainFitness training condition or the no-contact control condition. The training condition was asked to complete 40, 30-minute sessions over a 2-month period. Both conditions completed standard neuropsychological tests of attention/working memory, language, executive functioning, memory, and mood at baseline, after 2-months of training, and at 6-months of training. Results indicate that the training condition significantly improved in one objective measures of delayed recall (HVLT-R delayed recall). Results from time three data indicated that participants who trained on the Dakim BrainFitness program continuously over the 6-month period significantly improved in measures of delayed recall (HVLT, Rey-Osterrieth, Buschke, Verbal Pairs) when compared to those in the control group. This study indicates that the Dakim BrainFitness program may be effective at improving delayed recall, particularly for those who trained continuously over the 6-month period (Miller, et al., 2010).

Non-computerized cognitive stimulation. Besides computerized cognitive training, another type of cognitive intervention is non-computerized cognitive stimulation. This type of cognitive intervention involves enhancing the environment and experiences of the older adult by providing cognitively-stimulating activities (Stine-Morrow, Parisi, Morrow, & Park, 2008). Research indicates that cognitively-stimulating leisure activities are associated with a decreased risk of dementia (Fabrigoule et al., 1995; Scarmeas, Levy, Tang, Manly, & Stern, 2001; Verghese et al., 2003; Wang, Karp, Winblad, & Fratiglioni, 2002). For example, a study by Verghese and colleagues (2003) examined the relationship between leisure activities and the risk of dementia among 469 community-dwelling older adults over the age of 75 who did not have a diagnosis of dementia at baseline. This study examined both cognitive- and physical-activity. At baseline, participants were interviewed regarding six cognitive activities (reading books or newspapers, writing for pleasure, doing crossword puzzles, playing board games or cards, participating in organized group discussions, and playing musical instruments), and 11 physical activities (playing tennis or golf, swimming, bicycling, dancing, participating in group exercises, playing team games such as bowling, walking for exercise, climbing more than two flights of stairs, doing housework, and babysitting). Results found that cognitive and physical activities including reading, playing board games, playing musical instruments, and dancing were associated with a reduced risk of dementia at the five year follow-up visit. In addition, results indicate that greater participation in the amount of cognitive activity performed was correlated with a smaller rate of decline in cognition, specifically in episodic memory.

Another study by Fabrigoule and colleagues (1995) examined the relationship between social and leisure activities and the risk of ensuing dementia diagnosis among 2,040 community residents aged 65 and older. Information regarding 10 social and leisure activities was collected at baseline and dementia assessments were obtained at a 1 and 3-year follow-up visit. Social and leisure activities included data on sports and gymnastics participation, traveling, visits to friends or family members, child care, and participation in golden age clubs or associations. Data was also collected on reading, watching television, playing parlor games, gardening, odd jobs, and knitting. Results found that all but one (golden age club participation) of the leisure and social activities were significantly associated with a decreased risk of dementia.

Although cognitive stimulation sounds promising, most research associating cognitively-stimulating activities to a decreased risk of dementia is correlational. Only a couple of studies have examined whether cognitively-stimulating activities can directly improve memory abilities (Craik et al., 2007; Fried et al., 2004; Levine et al., 2007; Stine-Morrow, Parisi, & Morrow, 2008; Stuss et al., 2007). One of these studies was conducted by Stine-Morrow and colleagues (2008) in which older adults were randomized to a program of cognitive stimulation, or a control condition. Fluid abilities, functions that reflect the capacities for insight into complex problem-solving tasks (Alwin & Hofer, 2008), were assessed with outcome measures of speed of processing (Letter and Pattern Comparison), reasoning (Letter Sets and Figure Classification and Everyday Problem Solving), working memory (Letter-Number Sequencing), visual-spatial processing (Card Rotation and Hidden Patterns), and fluency (Word Association, Ornamentation, and Opposites FAS, and Alternate Uses). Results indicate that relative to the controls, the experimental condition had a positive change in a composite measure of fluid ability from pre- to post-training but no changes in working memory were found. Thus, Stine-Morrow et al. (2008) provided some experimental evidence that engagement can mitigate age-related cognitive declines in fluid ability, but not memory performance specifically. Thus, to date, there still appears to be no evidence that cognitively-stimulating activities can directly improve memory abilities among older adults residing in independent-living facilities.

Unlike cognitively-stimulating activities, adaptive cognitive training programs may be more effective at enhancing memory abilities (Lövdén, et al., 2010; Valenzuela & Sachdev, 2009). Thus, it is questionable whether non-adaptive programs such as cognitively-stimulating activities, are capable of enhancing memory performance. Adaptive programs provide users with activities that maintain an optimal level of challenge in order to maximize potential benefits from training (Valenzuela & Sachdev, 2009). Activities that are too easy will not provide enough mental stimulation, whereas activities that are too hard only cause frustration and mental fatigue. Experimental studies examining the effects of cognitive-stimulation on memory performance among older adults are needed.

Mind Your Mind. A program of cognitive stimulation designed for older adults in the attempt to delay age-related cognitive decline is *Mind Your Mind* (Seagull & Seagull, 2007). This commercially-available program of pencil-and-paper exercises is geared toward the concept of “mental fitness” and contains practical exercises, factual knowledge, and strategic support for everyday situations that are designed to enhance older adults’ crystallized intelligence, and indices of fluid intelligence such as memory, verbal fluency, executive functioning, language processing, and visual perception. This program consists of 9 sections: Metacognition, Memory, Flexible Thinking, Perception, Using Language, Reasoning, Using Numbers, Spatial Relationships, and Communication. Unlike the computerized cognitive training programs, like Dakim BrainFitness that are adaptive, programs of cognitively-stimulating exercises, such as Mind Your Mind, are not.

Although the Dakim BrainFitness and Mind Your Mind programs sound promising, to date, there is only one study that has examined the efficacy of Dakim BrainFitness and none, to the best of our knowledge, that have examined the effectiveness of Mind Your Mind. Thus, this study examined the efficacy of a computerized cognitive training program, *Dakim BrainFitness,* and a program of non-computerized cognitive stimulation, *Mind Your Mind,* to enhance memory performance among cognitively-intact older adults. The study compared groups of older adults trained in either the computerized or non-computerized program to a no-contact control group.

Study Hypotheses

Hypothesis One. Older adults randomized to cognitive training would experience significantly enhanced memory capabilities as measured by the Hopkins Verbal Learning Test (HVLT), the Auditory Verbal Learning Test (AVLT), and the Wechsler Memory Scale-Third Edition (WMS-III) Family Pictures subtest relative to those randomized to the cognitive stimulation or control conditions immediately post-training.

Hypothesis Two. Older adults randomized to the Mind Your Mind program of cognitively-stimulating exercises would not experience significantly improved memory function as measured by the HVLT, AVLT, and the WMS-III Family Pictures Test compared to those randomized to the control condition immediately post-training.

Hypothesis Three. Older adults randomized to the cognitive training condition would maintain significantly enhanced memory capabilities as measured by the HVLT, AVLT, and WMS-III Family Pictures Test across time.

Chapter Two: Method

Recruitment and Sample

An informed consent statement approved by the USF Institutional Review Board was signed by all participants. This statement was provided to the participant at the beginning of their first session. Participants were given time alone to read over the statement. After the individual read the statement, the Research Assistant obtaining the informed consent summarized the information and briefly described the study in layman's terms as well as informed the individual about their rights as a research participant. The participant was asked if they had any questions about participating in the study. The Research Assistant answered any questions and asked the participant if they would like to participate in the study or if they would like to take more time to think about it. When the participant indicated interest in continuing with the study, the person obtaining consent signed the informed consent statement along with the participant. The participant received a copy of the informed consent statement. Any indication of unwillingness to participate was observed and respected.

Eighty-one participants aged 65 years and older residing in independent-living facilities were recruited from five locations throughout the Tampa Bay area by fliers and presentations. Of the 81 participants screened, seven were ineligible for the study. Of these seven, five of the participants were ineligible due to a score $\leq$ 23 on the Mini Mental State Exam (MMSE), one was ineligible due to inadequate vision, and one participant was ineligible due to prior participation in a brain fitness training study (See **Measures** section for details regarding inclusion criteria). Sampling and flow of participants are displayed in Figure 3.1.

Excluding those who refused (n = 20), were ineligible (n = 7), or missing data (n = 1) (see **Results** for details), analyses included 53 older adults between the ages of 65 and 96 years (*M* = 82.24 years, *SD* = 7.89 years) who completed baseline and immediately post-training visits. Years of education ranged from 11th grade to doctoral level (*M* = 15.39 years, *SD* = 2.53 years). The sample included 74% women, and was comprised of 98% Caucasians. The computerized cognitive training condition was comprised of 17 participants, the non-computerized cognitive stimulation condition was comprised of 19 participants, and the no-contact control condition was comprised of 17 participants. Demographics by training condition are reported in Table 3.1.

Inclusion criteria. The screening measures were used to ascertain that participants could adequately view the stimuli and had sufficient cognitive functioning to complete the training requirements. Individuals 65 years of age and older were eligible to participate. In addition, because the intervention programs included instructions and stimuli in English only, all participants were required to be Native English speakers, as indicated by self-report.

The Mini Mental State Exam (MMSE; Folstein, Folstein, & McHugh, 1975) is widely used as a screening instrument for cognitive functioning. Scores reflect abilities in delayed recall, orientation, registration, attention, language, and construction. Scores range from 0 to 30 but only participants who score 23 or higher were eligible for the study (Folstein, et al., 1975). Higher scores indicate better cognitive performance.

Near visual acuity was assessed using a standard near vision letter chart via routine procedures with optical correction (if applicable). Based on previous cognitive training studies (Edwards et al., 2005), a score of 20/80 or better was required for participation in the study.

Hearing assessment. Hearing sensitivity was assessed using a portable audiometer. Pure-tone hearing thresholds were measured 1,000 and 2,000 Hz, the pitch range in which many important speech cues fall, without using a hearing aid.

Montreal Cognitive Assessment. The Montreal Cognitive Assessment (MoCA) is a measure of cognitive status. This measure assesses different cognitive domains including attention and concentration, executive function, memory, language, visuoconstructional skills, conceptual thinking, calculations, and orientation. Total score ranges from 0 to 30 points, with higher scores indicating better overall cognitive functioning.

Memory Measures. In past memory training studies, the AVLT and the HVLT were frequently used with older adults to measure auditory episodic STM and LTM (e.g., Ball, et al., 2002; Becker, McDougall Jr., Douglas, & Arheart, 2008; Duff, Beglinger, Moser, Schultz, & Paulsen, 2010; Rasmusson, et al., 1999; Rebok, Rasmusson, Bylsma, & Brandt, 1997; Smith et al., 2009). These tests are sensitive to memory impairment (Schmidt, 1996) and assess free recall

(AVLT and HVLT), recognition (HVLT), and learning (AVLT and HVLT). According to the large-scale ACTIVE study conducted by Ball and colleagues (2002), test-retest reliability for the AVLT is .73 and .78 for the HVLT. Visual episodic STM and LTM, on the other hand, can be assessed by the Family Pictures subtest of the Wechsler Memory Scale-III (WMS-III; Wechsler, 1997). The average test-retest reliability for Family Pictures immediate recall is .66 and .71 for Family Pictures delayed recall (Lichtenberger, Kaufman, & Lai, 2002).

AVLT. The AVLT (Rey, 1964, cited in Spreen & Strauss, 1991) was used to measure immediate recall and learning. In the learning phase, participants were presented with 15 unrelated words. Immediately after the first presentation, the participants were asked to repeat as many words as possible. The participant was read the same list of words four more times. During the 6^{th} trial, participants were given a second list of words to immediately recall. In the 7^{th} immediate recall trial, participants were to recall as many words as they could remember from the first list without hearing the words again. After a 15 minute delay, the participants were asked to recall as many words from the first list as possible. Scores range from 0 to 15 for each trial. Higher scores on the AVLT indicate better recall. A total score from trials 1-5 and 7 were used in analyses for immediate recall and the score from trial 8 was used for delayed recall in analyses.

HVLT. The HVLT (Brandt, 1991) involves a list of 12 words that fit into three different semantic categories. The HVLT required participants to listen to a list of words and immediately recall them. Three trials were completed and the total number of words correctly recalled from each trial was used in analyses. Higher scores indicated better immediate recall.

WMS-III Family Pictures*.* The WMS-III Family Pictures subtest (Wechsler, 1997) was used to assess visual memory and learning. Participants were first shown a picture of seven family members they would be seeing in upcoming scenes. In each of the four scenes they viewed a picture with four family members in it. The participants had ten seconds to remember as much as they could about each scene. After viewing each scene, participants were asked to recall which family members were in each scene, where they were each located, and what each of them was doing. Participants were asked to recall the items immediately after viewing all four scenes and after a twenty minute delay. Scores range from 0 to 64 for both the immediate and delayed recall. Higher scores indicate better immediate and delayed recall.

Training Conditions

Dakim BrainFitness*.* The Dakim BrainFitness program trains six cognitive domains primarily designed to enhance memory; STM, LTM, language processing, computation, visuospatial orientation, and critical thinking. Games of STM aim to improve recognition and recall abilities, whereas games of LTM include multiple types of recall exercises. The exercises played in games of language processing focus on oral language skills, definitions, translations, abstraction, reading comprehension, associations, and spelling. Computation games include exercises that focus on arithmetic, calculation, and mathematical concepts, whereas games of visuospatial orientation include identifying figures and objects presented in different formats. Finally, games of critical thinking focus on exercises of digit-symbol pairing, and grouping familiar objects according to certain rules or criteria. During each training session, participants completed games in multiple domains. Sessions were balanced in terms of pictures seen and words heard. All exercises were adaptive.

Difficulty varies by category and is based on user performance. Tasks are made more difficult by increasing the difficulty of the question and the amount of concrete and distracter answer choices given to the user. For example, a user may perform at a level 3 for computation and at a level 2 for LTM. The program adapts to how the user is performing on a trial by trial basis. If the user is performing well in a certain category, harder questions and answer choices will be given, making the level of challenge appropriate to their performance. In contrast, if a user is performing poorly, the program will automatically give them easier questions to maintain the optimal level of challenge. Dakim Inc. provided the BrainFitness systems for training at the independent-living facilities where participants resided.

The Dakim BrainFitness program has pre-set training sessions lasting 25 minutes in length. For training, each participant had an account for the Dakim BrainFitness program and asked to complete 5, 25-minute sessions per week (2-hours total). Every training session each participant completes is logged in the Dakim database. This provided an accurate measure of total training time completed for each participant.

Mind Your Mind*.* The Mind Your Mind program consists of non-technological cognitively-stimulating exercises designed to enhance older adults' crystallized intelligence, and indices of fluid intelligence such as memory, verbal fluency, executive functioning, language processing, and visual perception. The program consists of nine sections: Metacognition, Memory, Flexible Thinking, Perception, Using Language, Reasoning, Using Numbers, Spatial Relationships, and Communication.

The first three sections of the Mind Your Mind program include the Metacognition, Memory, and Flexible Thinking. The Metacognition section contains exercises designed to help with awareness of thinking skills, improve the ability to observe and think about ones thoughts, and to enhance communicating skills. The Memory section is divided into two sub-sections; retrieval and information processing. The retrieval sub-section is designed to help individuals retrieve and recall information that is stored in memory, guide the retrieval process, and reduce Tip-of-the-Tongue syndrome. The information processing sub-section of Memory is designed to help remember names, improve STM, and apply strategies for remembering. Flexible Thinking exercises are designed to help find new and different approaches to everyday life, open new pathways in the brain, and activate pathways that are weak.

The next three sections include Perception, Using Language, and Reasoning. The perception section contains exercises designed to enhance observation skills, reinforce concentration skills, and improve accuracy and speed in perceptual tasks. The Using Language section contains exercises that are designed to help work on word fluency, discover alternative or multiple meanings for words, and build vocabulary. The Reasoning focuses on logical thinking and systemic thought. Exercises are designed to improve confidence in problem solving abilities, and practice problem solving tasks involving logic.

The last three sections in the Mind Your Mind program include Using Numbers, Spatial Relationships, and Communication. Using Numbers focuses on everyday arithmetic and strategies. Exercises include practice problems on arithmetic fundamentals, mathematical thought, and problems to help improve accuracy and speed with numbers. Spatial Relationship exercises focus on shape recognition, direction, and location, as well as map reading. Participants perform exercises that explore different shapes and their relationships to each other, recognize directional locations and frames of reference, and practice reading maps. Lastly, the Communication section focuses on careful listening, following and giving directions, and expanding vocabulary. Exercises include transferring information to others using systemic thought and precise language, improving listening abilities, giving organized and coherent directions, becoming aware of body language, and making effective use of words to convey ideas.

Each of the nine sections contain a list of the goals and objectives for the skill, a contents list for the section, a rationale explaining the skill and its importance, exercises designed to give practice in the skill, self-help strategies and suggestions for solving everyday problems, and a reflective assessment.

The Mind Your Mind exercises were divided into 10, 2-hour sections where each section contained a weeks’ worth of activities (5, 25-minute sessions). Participants were asked to record the date and time spent for every session. Exercises were balanced in terms of pictures and word tasks and were not speeded or adaptive.

Procedure

Participants were recruited from multiple senior-living communities around the greater Tampa Bay area. Participants who met the inclusion criteria completed a baseline assessment of memory performance. At the end of this visit, participants were randomized to one of three conditions; immediate computerized cognitive training, immediate non-computerized program of cognitively-stimulating activity, or delayed no-contact control condition. Participants in the two immediate training conditions began training after the screening visit. While training participants received a phone call at weeks three, six, and nine to check on their progress. Approximately six weeks after baseline testing, participants in the delayed control condition received a phone call and letter informing them that their participation was valuable and would begin their training after the second testing visit. A script was used for all phone contacts.

The training protocol consisted of 20 hours of exercises. Training was completed in 25-minute sessions, five times a week, for a 10 week period. Participants were allowed to take breaks during the training session if needed. Immediately following the intervention phase (or an equivalent delay), memory performance was assessed. As stated in hypotheses one and two, we predicted that the cognitive training condition, and not the cognitive stimulation condition, would demonstrate significant improvements in memory performance immediately post-training. Therefore, memory outcome measures are only assessed at 3-months post-training among those randomized to the cognitive training condition.

Power Analyses

Preliminary analysis from a pilot study indicated a medium effect size of cognitive training using the Dakim BrainFitness to improve WMS-III Family Pictures-Delayed Recall performance (d = .58). Small effect sizes for the cognitive training program to improve performance on WMS-III Family Pictures immediate recall (d = .41), AVLT (d = .53), and HVLT (d = .64) were also found. An estimated 50 people (about 16 in each condition) are needed to detect the medium effect size (d = .58) as statistically significant with 95% power with two-tailed statistical tests.

Analyses

To analyze the outcome measures using the same scale, memory outcome scores were transformed into standardized z-scores. Additionally, to avoid distorted statistics and lower the chance of having a Type 1 or II error (Tabachnick & Fidell, 1996), any outliers that exceeded ± 2.5 standard deviations from the mean (2-tailed) were recoded to +2.5z or -2.5z.

Potential covariates. A Multivariate Analyses of Variance (MANOVA) was conducted to determine whether there were any baseline differences among the three training conditions (cognitive training, cognitive stimulation, and control) at baseline on characteristics of age, education, hearing, cognitive status, near visual acuity, and the memory outcome measures (AVLT immediate and delayed recall, HVLT immediate recall, and WMS-III Family Pictures immediate and delayed recall). In this analysis, the baseline characteristics and memory outcome measures were the dependent variables while training condition was the independent variable. The three training conditions were also compared to see if there were differences in gender or race using Chi-square analysis.

Analyses for testing hypotheses one and two. To examine hypotheses one and two, a repeated measures MANOVA was used to compare the three training conditions on memory outcome measures (AVLT immediate and delayed recall, HVLT immediate recall, and WMS-III Family Pictures immediate and delayed recall) across testing occasions (baseline to immediately post-training). The independent variables were training condition and time of test. The dependent variables were the memory outcome measures (AVLT, HVLT, and WMS-III Family Pictures). For an overall significant group x time interaction indicating a training effect, follow-up repeated measures analyses for each memory outcome measure were conducted. Post-hoc analyses were conducted for any significant memory outcome measures using the Fisher's Least Significant Difference test (LSD) to determine which training conditions were significantly different.

Intent-to-treat analyses were used to test hypotheses one and two. All participants with complete data on the memory outcome measures were included in analyses regardless of training adherence.

Analyses for testing hypothesis three. To test hypothesis three, a repeated measures ANOVA was conducted with testing occasion (baseline, immediately post-training, and 3-months post-training) as the independent variable and the memory outcome measures as the dependent variables (AVLT, HVLT, and WMS-III Family Pictures). As stated in hypothesis three, only the cognitive training condition is included in these analyses. As with hypotheses one and two, intent-to-treat analyses was used to test hypothesis three. All participants with complete data on the memory outcome measures were included in analyses regardless of training adherence.

Chapter Three: Results

Attrition

Twenty participants refused to continue participation in the study between baseline and 3-months post-training. Of these 20 participants: seven refused because they were too busy; five refused due to health; two participants died; two were unable to be contacted; and three refused because they were either bored (n = 1) or did not like participating (n = 2). Of the three participants who refused because they were bored or disliked participating, two were randomized to the cognitive stimulation condition and one to the control condition. Across conditions, six of the refusals were randomized to the cognitive training condition, eight were in the cognitive stimulation condition, and four were in the control condition. Chi-square analysis indicated that the three training conditions did not significantly differ in the number of refusals, $\chi^2 = .549$, N = 18, $p = .68$. Refer to Figure 3.1 for details on participant flow.

Missing Data and Outliers

Any participants with missing data from the memory outcome measures were excluded from analyses. There was one missing data point for the AVLT immediate recall, one missing data point for AVLT delayed recall, and no missing data points for the HVLT or WMS-III Family Pictures (immediate and delayed recall). In addition, four outcome scores were considered outliers and recoded to $\pm$ 2.5 z. One outlier was re-coded at baseline for the WMS-III Family Pictures immediate recall and three outliers were recoded at baseline for the WMS-III Family Pictures delayed recall. After these adjustments, fifty-three participants completed the study and were included in analyses. Thus, there were a total of 17 participants in the cognitive training condition, 19 in the cognitive stimulation condition, and 17 in the control condition for analyses.

Training Completion

The amount of training time across the cognitive training and cognitive stimulation training conditions ranged from 0 to 56 hours (*M* = 20.48, *SD* = 12.3). For the cognitive training condition, training completion time between baseline and immediately post-training ranged from 0 to 56 hours (*M* = 23.91, *SD* = 9.33). Training completion time for the cognitive stimulation condition ranged from 0 to 52.5 hours (*M* = 21.08, *SD* = 12.55). Analysis using an Independent Samples *t*-test indicates that the cognitive training and cognitive stimulation conditions did not significantly differ in the amount of training time completed between baseline and immediately post-training, $t(30) = -.729$, $p = .471$. To test the study hypotheses, intent-to-treat analyses were conducted. Therefore, no participants were excluded from analyses due to the lack of training adherence.

Covariates

Chi-square indicated that the three training conditions were not significantly different in gender, χ^2 (2, N = 54) = 1.14, $p = .565$, or race, χ^2 (2, N = 54) = 1.88, $p = .391$.

When MANOVA was used to compare the three training conditions across baseline characteristics (age, education, cognitive status, near visual acuity) and memory measures (AVLT, HVLT, and WMS-III Family Pictures), results indicated no significant group differences, Wilks' Λ = .722, $F(18,84) < 1$, $p = .660$, partial $\eta^2 = .150$. Thus, the three training conditions did not significantly differ at baseline and no baseline characteristics were used as covariates in the analyses to test hypotheses one and two. Means and standard deviations for baseline characteristics by condition are reported in Table 3.1.

Hearing Sensitivity

Hearing sensitivity was added approximately half-way through the study. Therefore, hearing sensitivity was assessed in only 39 (72%) of the participants. Of these 39 participants, nine were in the cognitive training condition, 19 were in the cognitive stimulation condition, and 11 were in the control condition. Among the subset of participants that completed the hearing assessment (n = 39), a MANOVA was conducted to determine whether hearing thresholds (right ear 1,000 and 2,000 Hz, left ear 1,000 and 2,000 Hz) significantly differed across the three training conditions (cognitive training, cognitive stimulation, control). Results indicated no overall group difference, Wilks' Λ = .729, $F(8,66) = 1.41$, $p = .209$, partial $\eta^2 = .146$. Because there were not any baseline differences between the three conditions, no covariates were used in subsequent analyses.

Hypotheses One and Two

To examine hypotheses one and two, a repeated measures MANOVA was used to compare the three training conditions (cognitive training, cognitive stimulation, control) across memory outcome measures (AVLT, HVLT, and WMS-III Family Pictures) from baseline to immediately post-training. Results indicated no significant effects of group, Wilks' Λ = .793, $F(10,92) = 1.13$, p = .347, partial η^2 = .110, or time, Wilks' Λ = .957, $F(5,46) < 1$, p = .839, partial η^2 = .043. A significant group x time interaction, Wilks' Λ = .585, $F(10,92) = 2.83$, p = .004, partial η^2 = .235, was found. This indicates that the three training conditions were significantly different across pre- to immediately post-training on the memory outcome measures.

Follow-up analyses using repeated measures ANOVA for each memory outcome measure from baseline to immediately post-training were conducted. Means and standard deviations for the three training conditions on the memory measures at baseline and immediately post-training are reported in Table 3.2.

AVLT Immediate recall. For AVLT immediate recall there was no significant effect of group, $F(2,50) < 1$, p = .628, partial η^2 = .018, no significant effect of time, $F(1,50) = 1.116$, p = .296, partial η^2 = .022, and no significant group x time interaction $F(2,50) = 2.544$, p = .089, partial η^2 = .092. Results indicate that the three training conditions did not differ significantly on the AVLT immediate recall (p = .089). Mean z-scores for the AVLT immediate recall at baseline and immediately post-training are presented in Figure 3.2.

AVLT Delayed recall. For AVLT delayed recall, no significant effect of group, $F(2,50) < 1$, p = .865, partial η^2 = .006, no significant effect of time, $F(1,50) < 1$, p = .822, partial η^2 = .001, but a significant group x time interaction, $F(2,50)$ = 3.683, p = .032, partial η^2 = .128. Post-hoc comparisons with Fisher's LSD test indicated that the cognitive training condition performed significantly better than the cognitive stimulation condition on the AVLT delayed recall immediately post-training (p = .012). No significant difference was found between the cognitive training and the no-contact control condition (p = .198). Neither was a significant difference found between the cognitive stimulation and control condition (p = .206). Mean z-scores for the AVLT delayed recall at baseline and immediately post-training are presented in Figure 3.3.

HVLT. For HVLT immediate recall there was no significant effect of group, $F(2,50) = 2.370$, $p = .104$, partial $\eta^2 = .087$, no significant effect of time, $F(1,50) < 1$, $p = .349$, partial $\eta^2 = .018$, but a significant group x time interaction, $F(2,50) = 5.059$, $p = .010$, partial $\eta^2 = .168$. Post-hoc comparisons with Fisher's LSD test indicated significantly better performance for the cognitive training condition than the cognitive stimulation condition ($p < .001$), and as compared to the control condition (p .011) on the HVLT immediately post-training. No significant differences were found between the cognitive stimulation and control condition ($p = .151$) on the HVLT immediately post-training. Mean z-scores for the HVLT immediate recall at baseline and immediately post-training are presented in Figure 3.4.

WMS-III Family Pictures Immediate recall. For WMS-III Family Pictures immediate recall, there was no significant effect of group, $F(2,50) = 1.198$, $p = .310$, partial $\eta^2 = .046$, no significant effect of time, $F(1,50) < 1$, $p = .556$, partial $\eta^2 = .007$, and no significant group x time interaction, $F(2,50) < 1$, $p = .808$, partial $\eta^2 = .009$. Results indicate that the three training conditions did not differ significantly on WMS-III Family Pictures immediate recall. Mean z-scores for the

WMS-III Family Pictures immediate recall at baseline and immediately post-training are presented in Figure 3.5.

WMS-III Family Pictures Delayed recall. For WMS-III Family Pictures delayed recall there was a no significant effect of group $F(2,50) = 1.424$, $p = .250$, partial $\eta^2 = .054$, no significant effect of time, $F(1,50) < 1$, $p = .362$, partial $\eta^2 = .017$, and a marginally significant group x time interaction, $F(2,50) = 2.975$, $p = .060$, partial $\eta^2 = .106$. Fisher's LSD test indicated significantly better performance for the cognitive training condition than the control condition ($p = .030$) on the WMS-III Family Pictures delayed recall measure immediately post-training. There were no significant differences between cognitive training and cognitive stimulation conditions or between the cognitive stimulation and control conditions (*p*s > .05). Mean z-scores for the WMS-III Family Pictures delayed recall at baseline and immediately post-training are presented in Figure 3.6.

Hypothesis Three

Repeated measures ANOVA revealed no significant main effect of time for participants in the cognitive training condition, Wilks' $\Lambda = .47$, $F(6,11) = 2.11$, $p = .135$, partial $\eta^2 = .535$. These results suggest no overall changes on the outcome measures across time. Mean z-scores for the cognitive training condition on the memory outcome measures across time are displayed in Figure 3.7.

Table 3.1. Baseline Descriptive Means and Standard Deviations by Training Condition

Variable	Cognitive Training n = 17 M(SD)	Cognitive Stimulation n = 19 M(SD)	Control n = 17 M(SD)	Overall n = 53 M(SD)
Age	82.41(6.68)	81.32(9.68)	83.82(6.55)	82.24(7.89)
Education (in years)	15.06(2.56)	15.84(2.29)	15.18(2.88)	15.39(2.53)
Gender (% Female)	64.7%	78.9%	77.8%	74.1%
Race (% Caucasian)	100%	94.7%	100%	98.1%
Near Visual Acuity[†]	0.1529	0.1537	0.1500	0.1522
MMSE	28.18(1.98)	27.58(2.01)	27.22(2.02)	27.65(2.00)
Cognitive Status[††]	25.53(3.06)	23.74(3.84)	24.12(3.46)	24.43(3.51)

Notes: M=mean, SD=standard deviation; [†]Near Visual Acuity is reported in LogMAR scores. [††]Cognitive status was assessed by the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005)

Table 3.2. Baseline Mean and Standard Deviations for Memory Outcome Measures across Training Condition

	Cognitive Training n = 17	Cognitive Stimulation n = 19	Control Condition n = 17	Total n = 53
Variable	M (SD)	M (SD)	M (SD)	M (SD)
AVLT Immediate Recall				
Baseline	49.29 (15.42)	48.05 (17.51)	48.00 (17.54)	48.43 (16.56)
Immediately Post-Training	59.88 (15.29)	50.84 (15.46)	54.82 (18.55)	55.02 (16.57)
AVLT Delayed Recall				
Baseline	6.47 (4.37)	7.47 (4.54)	6.29 (4.63)	6.77 (4.46)
Immediately Post-Training	9.12 (3.82)	7.53 (3.79)	7.82 (4.64)	8.13 (4.07)
HVLT Immediate Recall				
Baseline	23.53 (6.08)	21.53 (6.45)	23.24 (6.54)	22.72 (6.31)
Immediately Post-Training	25.76 (6.53)	18.68 (5.55)	22.24 (7.14)	22.09 (6.94)
Family Pictures Immediate Recall				
Baseline	33.24 (9.42)	28.26 (13.60)	29.82 (10.50)	30.36 (11.39)
Immediately Post-Training	35.88 (11.76)	29.63 (15.92)	29.71 (12.66)	31.66 (13.72)
Family Pictures Delayed Recall				
Baseline	32.53 (10.92)	26.00 (14.77)	30.06 (10.52)	29.40 (2.40)
Immediately Post-Training	37.53 (10.48)	30.95 (15.57)	29.24 (13.15)	32.51 (13.55)

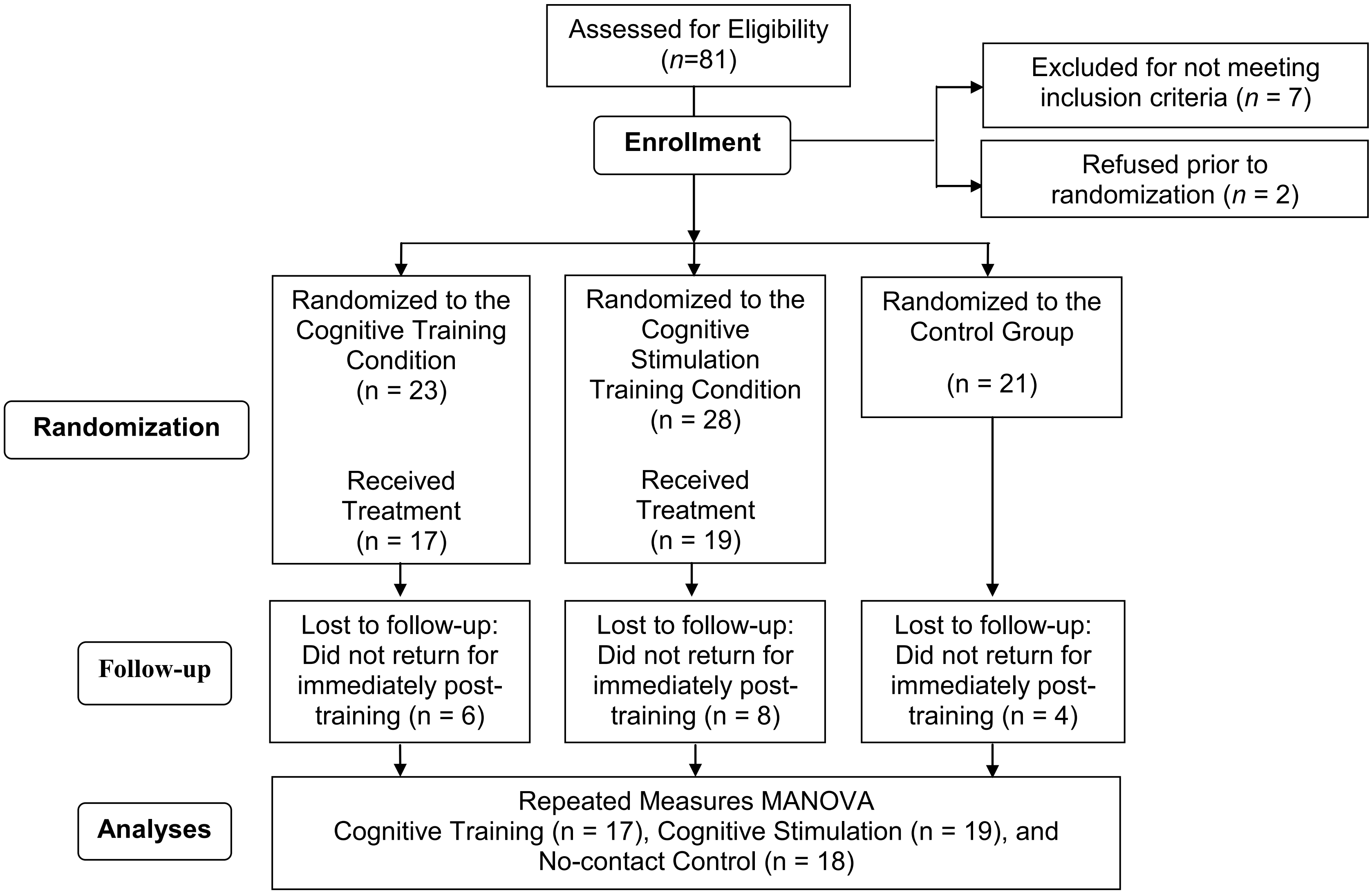

Figure 3.1. Sampling and Flow of Participants

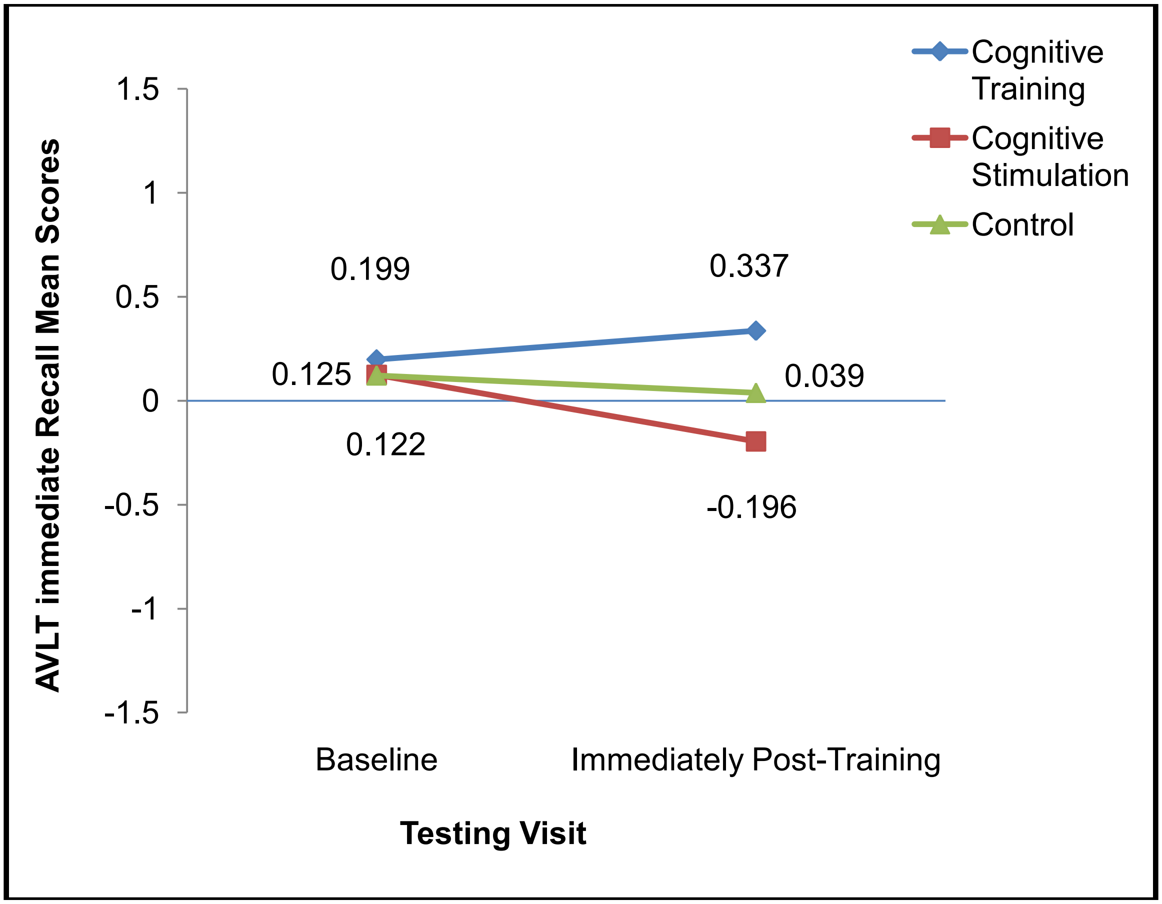

Figure 3.2. Mean z-scores for the AVLT Immediate Recall at Baseline and Immediately Post-Training

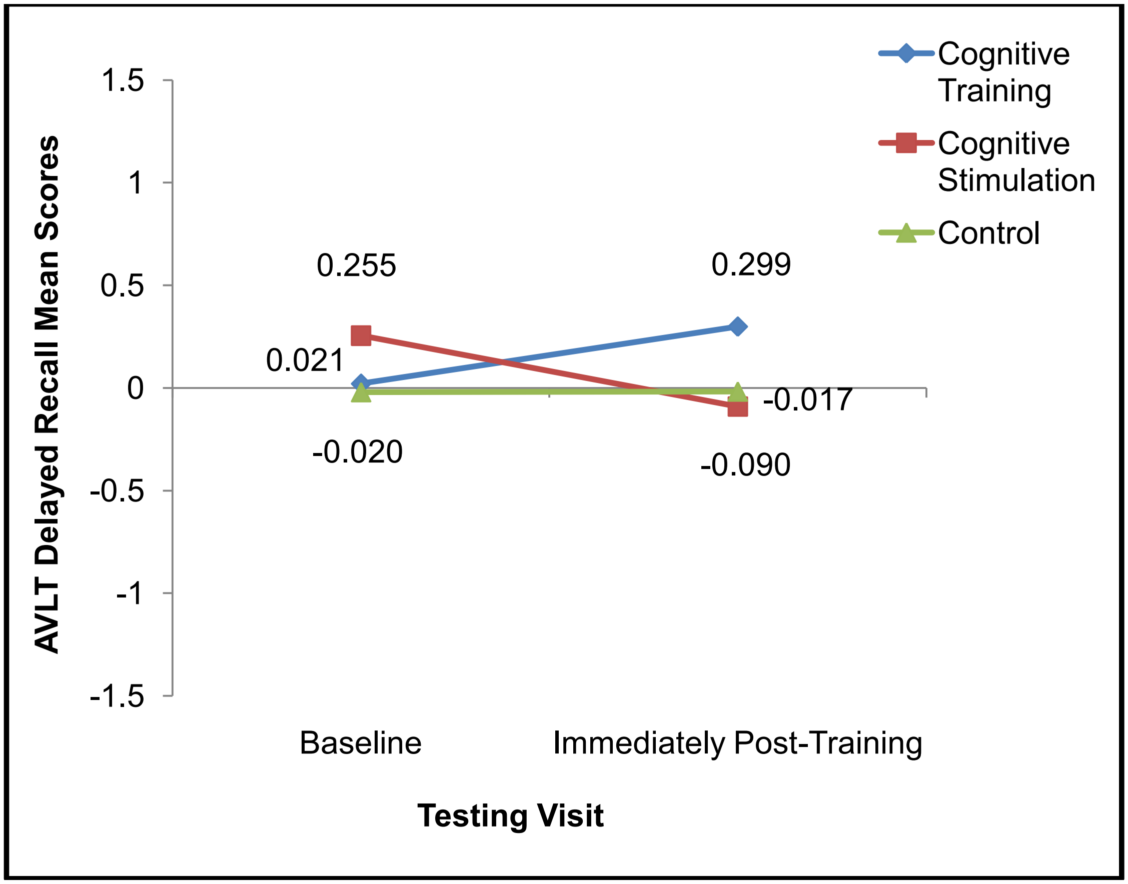

Figure 3.3. Mean z-scores for the AVLT Delayed Recall at Baseline and Immediately Post-Training

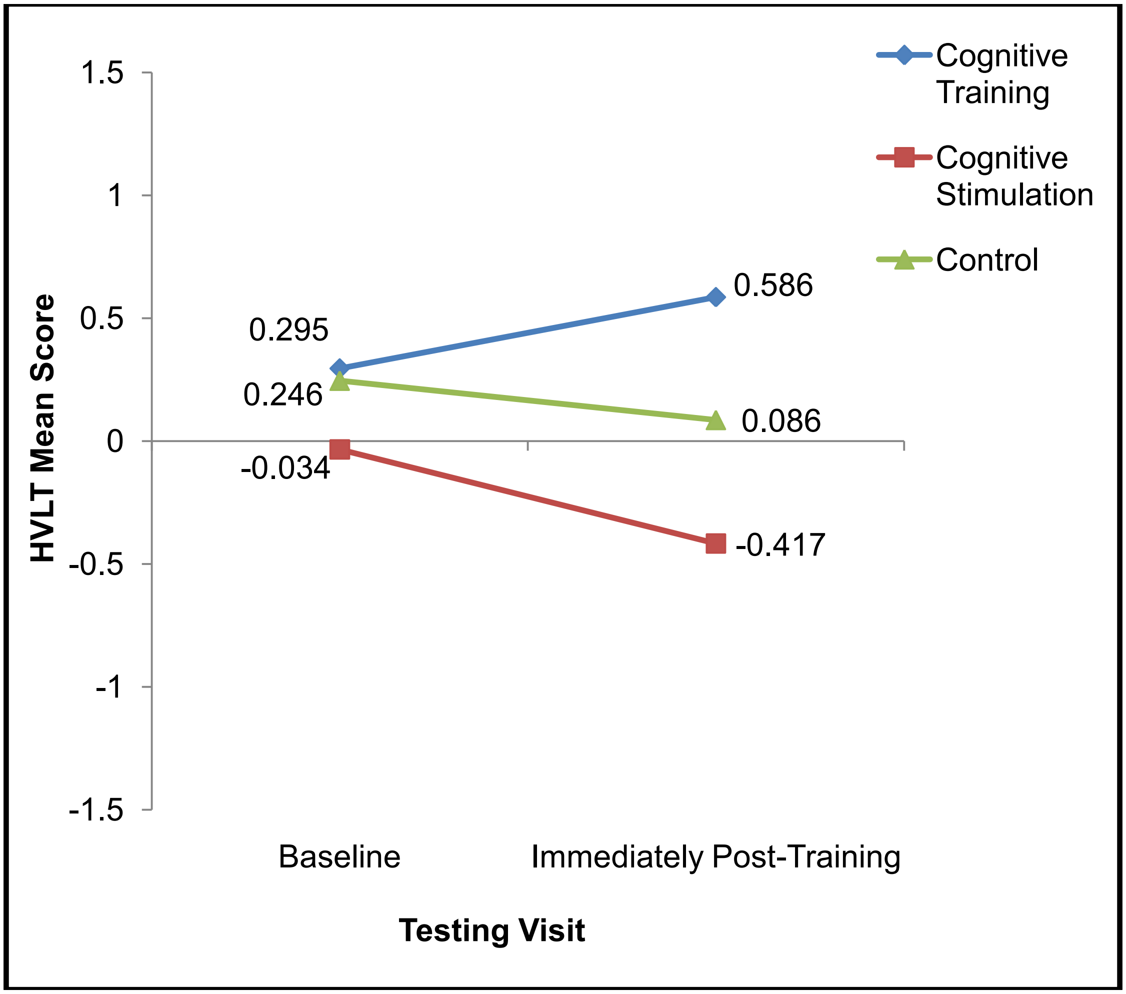

Figure 3.4. Mean z-scores for the HVLT Immediate Recall at Baseline and Immediately Post-Training

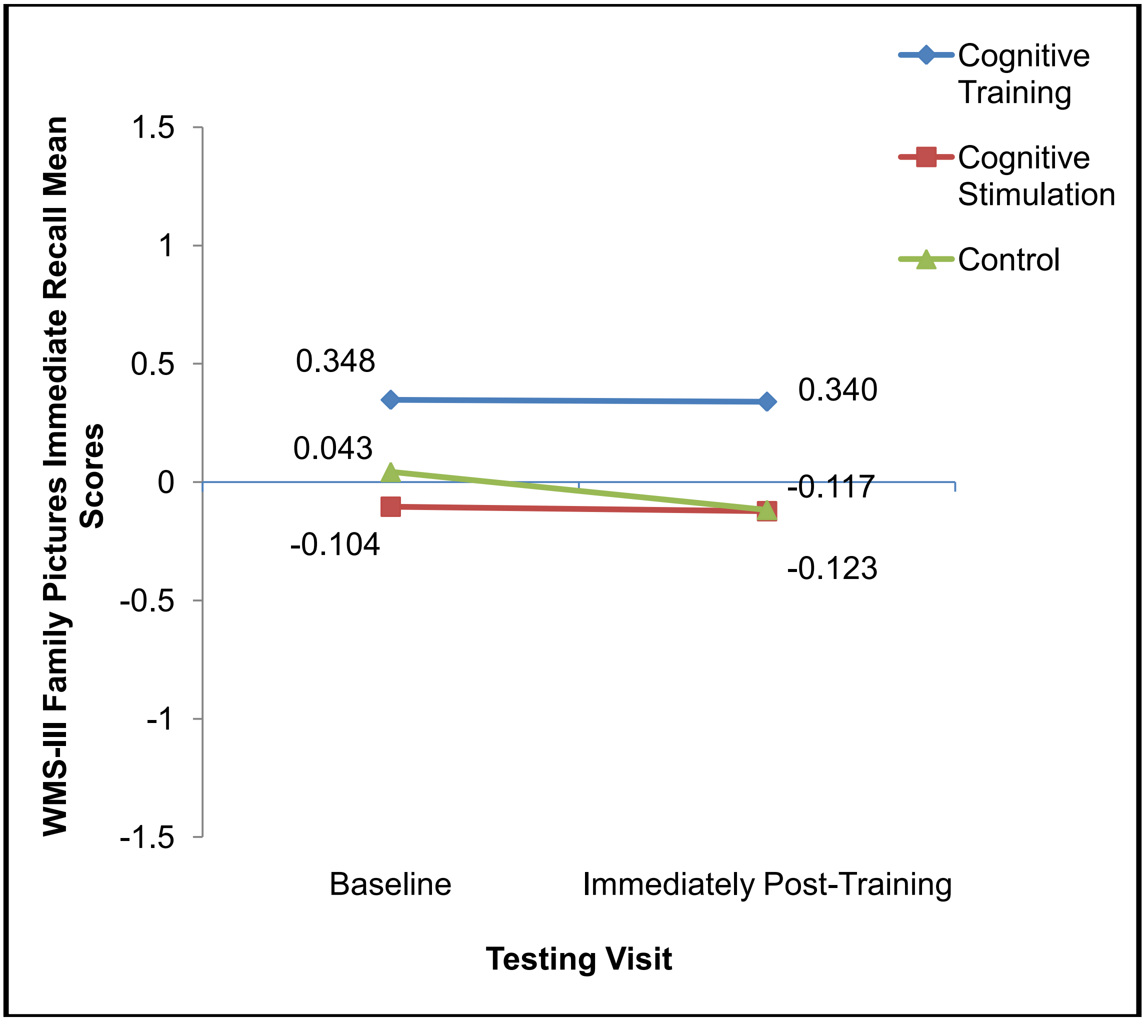

Figure 3.5. Mean z-scores for the WMS-III Family Pictures Immediate Recall at Baseline and Immediately Post-Training

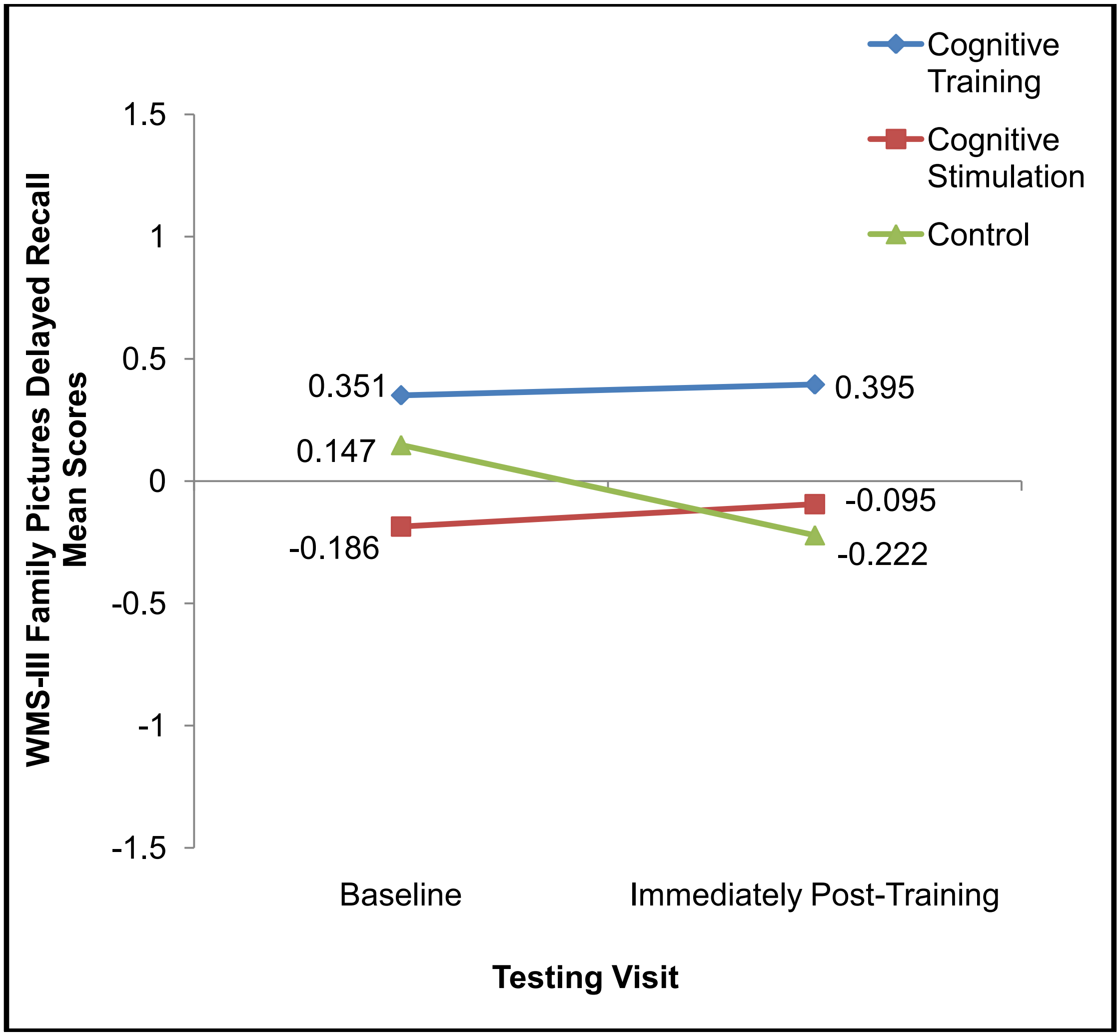

Figure 3.6. Mean z-scores for the WMS-III Family Pictures Delayed Recall at Baseline and Immediately Post-Training

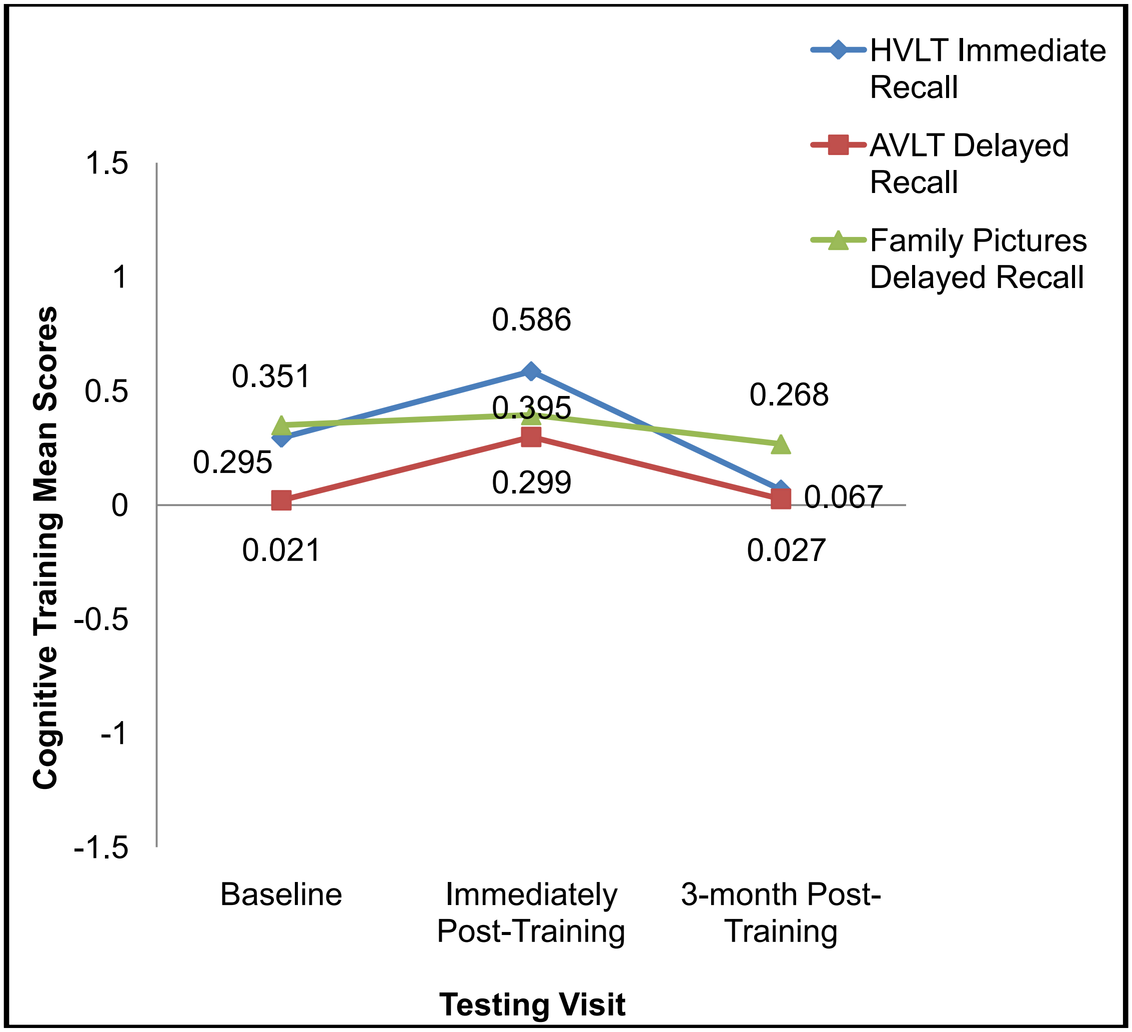

Figure 3.7. Scores on the Memory Outcome Measures across Time among the Cognitive Training Condition

Chapter Four: Discussion

This study examined whether two cognitive interventions, cognitive training and cognitive stimulation were effective at enhancing memory performance among cognitively-intact older adults residing in independent-living retirement communities. As discussed in chapter one, episodic STM, WM, explicit memory, and episodic LTM are negatively impacted with advancing age, but can be improved or maintained through cognitive interventions. Thus, it is important that cognitive interventions are clinically tested to determine whether programs such as cognitive training and cognitive stimulation can directly improve memory abilities among older adults.

Hypothesis One

Hypothesis one predicted that older adults randomized to the computerized cognitive training program, Dakim BrainFitness, would experience enhanced memory capabilities relative to the conditions receiving the non-computerized Mind Your Mind program of cognitively-stimulating activities or the no-contact control. Because the cognitive training condition did not perform significantly better on the entire battery of memory outcome measures, this hypothesis is only partially supported.

The BrainFitness cognitive training program significantly improved episodic memory abilities related to immediate recall of semantically-related lists of words, and delayed recall of non-related words. With regard to delayed recall results, participants in the cognitive stimulation and control conditions experienced declines from baseline to immediate-post-training which, in part, account for significant findings. Results also indicated that performance on the WMS-III Family Pictures delayed recall subtest from baseline to immediately post-training was significantly better for the cognitive training condition than the control conditions. Again, these findings can at least in part be attributed to declines in the control condition over this time period.

No significant differences were found on the memory outcome measures of AVLT immediate recall, and WMS-III Family Pictures immediate recall. These findings indicate that the Dakim BrainFitness program may not significantly improve episodic memory abilities when stimuli are visually-presented (immediate or delayed). Further, the training program did not affect the immediate memory of lists of unrelated words that were aurally presented. Thus, cognitive training using the Dakim BrainFitness program appears more effective at enhancing immediate recall of episodic semantically-related words among older adults.

With significant training effects observed in the cognitive training condition relative to the cognitive stimulation condition, as well as no differences between the cognitive stimulation and control conditions, this study provides support for the Model of Adult Plasticity. According to this theory, in order to improve cognitive performance, brain exercises need to be adaptive so that there is a continuous mismatch between the individuals' cognitive capacities and the demands of the task.

Results from this study coincide with the results of Miller and colleagues (2010) who found that the Dakim BrainFitness program is effective at significantly improving auditory delayed recall, particularly for those who trained continuously over a 6-month period. Similar to the present findings, no training effects were found on visually-presented stimuli.

Hypothesis Two

The findings support the second hypothesis that older adults randomized to the Mind Your Mind program of cognitive stimulation would not experience significant improvements relative to the control condition. Unlike cognitive training, which adapts to each individuals level of performance and maintains an optimal level of challenge, the cognitive exercises completed by participants in the cognitive stimulation were likely not challenging enough or too hard to significantly enhance memory performance (Lövdén, et al., 2010; Valenzuela & Sachdev, 2009). This lack of mismatch between the individual's capacities and the demands of the task results in no significant changes in memory performance.

These study findings do not provide support for the engagement hypothesis, particularly in regard to memory measures with aurally-presented stimuli. Our results suggest that there were no significant effects of engaging in cognitively-stimulating activities compared to the control condition. On the contrary, from examination of Figures 3.2, 3.3, and 3.4, there was a tendency for decline in this condition on memory measures with aurally-presented stimuli.

According to the engagement hypothesis, cognitive training and cognitive stimulation effects would be similar, but this not reflected in our findings.

Hypothesis Three

The third hypothesis stated that memory training gains would endure for those who participated in cognitive training 3-months post-training relative to baseline. Analyses indicate that although there were some significant differences immediately post-training on the AVLT delayed recall, HVLT immediate recall, and WMS-III Family Pictures delayed recall (marginally significant), these training gains did not endure at 3-months post-training.

These results suggest that although the cognitive training program Dakim BrainFitness is able to immediately improve memory abilities, once use of the program is ceased, observed improvements in memory performance declined back to pre-training levels. Therefore, based on these findings, participants who wish to maintain memory performance over an extended period of time may need to continue use of the BrainFitness program on a regular basis or incorporate booster training (e.g., follow-up training sessions after the initial intervention period) as conducted in the ACTIVE study (Ball, et al., 2002).

Interestingly, there is a large degree of variance present in the current literature regarding the maintenance of training gains over time. As this study indicates, continued use of a training program may be the best method for maintenance. However, researchers claim that the best way for older adults to maintain training gains without continuous use of the training program is to teach skills they can use in their daily life (Anschutz, Camp, Markley, & Kramer, 1987;

Rebok, et al., 2007). Training programs that do not teach skills used on a daily basis will not likely show small long-term durability (Rebok, et al., 2007). For example, Anschutz, Camp, Markley, and Kramer (1987) found that 90% of their participants used the method of loci for remembering a word list during the study. However, participants failed to incorporate this method into their everyday life causing continued problems with recall tasks. In contrast, older adults who do continue to use the skills learned from training decline at a slower rate and experience gains for a longer period of time (Hall et al., 2009). Although the Dakim BrainFitness program teaches various memory training techniques, it may be that the skills taught are not being incorporated into the user's daily life.

Study Limitations

There are notable limitations to this study. First, because the cognitive training program was not available for individual use, the study was restricted to senior housing locations in which one computer could be used by multiple older adults. As a result, the sample is comprised of mostly Caucasian females, which represents the typical older adult residing in independent-living facilities. Therefore, this sample may not generalize to community-based older adults who are a minority or of male gender.

Second, a known limitation to longitudinal studies, especially ones that require a good degree of commitment by participants, is attrition. Although we expected some degree of attrition, there was a larger amount of refusals (25.3%) than expected. As noted in the results section, participants refused participation in the study for various reasons but mostly due to poor health or the time commitment required.

Third, this study administered the same measure across three time points. Different versions of each outcome measure would be preferred to reduce practice effects. Although the AVLT and HVLT have multiple versions, the WMS-III Family Pictures subtest does not. Therefore, participants in the study may have experienced greater practice effects to the WMS-III Family Pictures subtest than the AVLT and HVLT. It is our assumption, however, that the use of a control condition would account for the impact of practice effects.

Fourth, the influence that computerized versus non-computerized stimuli has on training gains are unknown. One advantage of computerized cognitive training programs is the ability to make the activities enjoyable through animation, graphics, and auditory stimuli. It is possible that participants in the cognitive training program found the training more enjoyable, causing them to focus on the material more than the paper and pencil programs of cognitive stimulation.

Fifth, with a sample of only 53 older adults, power to detect small effect sizes was limited. The lack of significant results at 3-months post-training could also be due to the small longitudinal sample size (n = 17). As previously explained, an estimated 50 people (about 16 in each condition) was needed to detect a medium effect size (d = .58) as statistically significant with 95% power with two-tailed statistical tests. However, a larger sample size would increase the statistical power and reduce the chance of Type I error. Thus, a larger sample would improve the validity of the study.

Finally, this study examined the effects that two cognitive interventions have on memory performance. The impact that these cognitive interventions have on other cognitive domains such as processing speed, critical thinking, computation, visuospatial orientation, and language abilities is also important. Information regarding these training programs' direct effects as well as indirect effects such as the transfer of training gains to functional domains is unknown and should be investigated.

Future Research in Cognitive Interventions

Even though progress has been made in the field of memory training over the years, there are still some changes that can continue to move this field forward. To start, a missing component to current training approaches pertains to the use of multiple methods. Rebok and colleagues (2007) suggest that combining memory training with areas such as pharmacotherapy, lifestyle changes, and exercise programs may enhance the benefits of training in more than one area of health. Although only a few studies have attempted this type of approach, results are promising. For example, studies that use physical training (both aerobic and anaerobic activity) have found reduced risks of cognitive decline and increased memory performance (Abbott et al., 2004; Colcombe & Kramer, 2003; Dik, Deeg, Visser, & Jonker, 2003; Podewils et al., 2005; Weuve et al., 2004). This evidence suggests that multi-domain training techniques may be the ideal way to extend benefits of training to other areas of health (Lustig & Flegal, 2008).

Although there are many factors related to the administration of assessments (i.e. testing competency in English, and testing vision at baseline), hearing deficits are noted as the primary predictor of speech recognition (Akeroyd, 2008). Thus, older adults who experience hearing loss will likely have difficulties in recognizing speech, which directly impacts memory performance. How much a person remembers depends on the organization and richness of encoded information (Craik, 2007). In other words, if hearing is poor, comprehension will suffer and result in poorer memory (Craik, 2007). Therefore, it is important to address factors related to hearing difficulties. Two possible ways to do this is by controlling for hearing ability or using standardized recorded voice measurements (Roeser & Clark, 2008). Studies show that recorded presentations of stimuli are superior to live voice presentations due to standardization and greater reliability in obtained scores (Akeroyd, 2008; Brandy, 1966; Penrod, 1979). Therefore, training intervention studies need to address the impact that hearing abilities may have on memory intervention outcomes.

Conclusion

This study examined whether two cognitive interventions, cognitive training and cognitive stimulation, were effective at enhancing memory performance. This study found that the adaptive cognitive training program, Dakim BrainFitness, was effective at enhancing memory performance as measured by AVLT delayed recall, HVLT immediate recall, and WMS-III Family

Pictures delayed recall. There was no evidence that the non-adaptive program of cognitive stimulation, Mind Your Mind, is effective at significantly improving memory performance. These findings coincide with the Model of Adult Cognitive Plasticity that in order to improve cognitive performance, brain exercises need to be adaptive so that there is a continuous mismatch between the individual's cognitive capacities and the demands of the task.

List of References

Abbott, R. D., White, L. R., Ross, G. W., Masaki, K. H., Curb, J. D., & Petrovich, H. (2004). Walking and dementia in physically capable elderly men. *Journal of the American Medical Association, 292*, 1447-1453. doi: 10.1001/jama.292.12.1447

Akeroyd, M. A. (2008). Are individual differences in speech reception related to individual differences in cognitive ability? A survey of twenty experimental studies with normal and hearing-impaired adults. *International Journal of Audiology, 47*(Supplement 2), S53-S71. doi: 10.1080/14992020802301142

Alwin, D. F., & Hofer, S. M. (2008). Opportunities and challanges for interdisciplinary research. In S. M. Hofer & D. F. Alwin (Eds.), *Handbook of Cognitive Aging: Interdisciniplinary Perspectives* (pp. 2-31). Los Angeles: SAGE Publications.

Anschutz, L., Camp, C. J., Markley, R. P., & Kramer, J. J. (1987). Remembering mnemonics: A three-year follow-up on the effects of mnemonics training in elderly adults. *Experimental Aging Research, 13*(3), 141-143. doi: 10.1080/03610738708259315

Baddeley, A., & Hitch, G. (1974). Working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 8, pp. 47-89). New York: Academic Press.

Ball, K., Berch, D. B., Helmers, K. F., Jobe, J. B., Leveck, M. D., Marsiske, M., . . . Willis, S. L. (2002). Effects of cognitive training interventions with older adults: A randomized controlled trial. *JAMA, 288*(18), 2271-2291. doi: 10.1001/jama.288.18.2271

Balota, D. A., Dolan, P. O., & Duchek, J. M. (2000). Memory changes in healthy older adults. In E. Tulving & F. I. M. Craik (Eds.), *The Oxford Handbook of Memory* (pp. 395-410). Oxford: Oxford University Press.

Balota, D. A., Duchek, J. M., & Paullin, R. (1989). Age-related differences in the impact of spacing, lag, and retention interval. *Psychology and Aging, 4*(1), 3-9. doi: 10.1037/0882-7974.4.1.3

Becker, H., McDougall Jr., G., Douglas, N. E., & Arheart, K. L. (2008). Comparing the efficacy of eight-session versus four-session memory intervention for older adults. *Archives of Psychiatric Nursing, 22*(2), 87-94. doi: 10.1016/j.apnu.2007.05.003

Bond, G. E., Wolf-Wilets, V., Fiedler, F. E., & Burr, R. L. (2000). Computer-aided cognitive training of the aged: A pilot study. *Clinical Gerontologist, 22*(2), 19-42. doi: 10.1300/J018v22n02_03

Bopp, K. L., & Verhaeghen, P. (2005). Aging and verbal memory span: A meta-analysis. *Journal of Gerontology: Psychological Sciences, 60B*, P223-P233. doi: 10.1093/geronb/60.5.P223

Brandt, J. (1991). The Hopkins Verbal Learning Test: Development of a new memory test with six equivalent forms. *Clinical Neuropsychology, 5*, 125-142. doi: 10.1016/S0887-6177(98)00004-3

Brandy, W. (1966). Reliability of voice tests of speech discrimination. *Journal of Speech and Hearing Research, 9*, 461-465. Retrieved from http://jslhr.highwire.org/.

Brickman, A. M., & Stern, Y. (2009). Aging and Memory in Humans Vol. 1. L. R. Squire (Ed.) *Encyclopedia of Neuroscience* (pp. 175-180).

Buschkuehl, M., Jaeggi, S. M., Hutchison, S., Perrig-Cjiello, P., Dapp, C., Muller, M., . . . Perrig, W. J. (2008). Impact of working memory training on memory performance in old-old adults. *Psychology and Aging, 23*(4), 743-753. doi: 10.1037/a0014342

Carretti, B., Borella, E., & De Beni, R. (2007). Does strategic memory training improve the working memory performance of younger and older adults? *Experimental Psychology, 54*(4), 311-320. doi: 10.1027/1618-3169.54.4.311

Colcombe, S., & Kramer, A. F. (2003). Fitness effects on the cognitive function of older adults: A meta-analytic study. *Psychological Science, 14*(2), 125-130. doi: 10.1111/1467-9280.t01-1-01430

Colsher, P. L., & Wallace, R. B. (1991). Longitudinal application of cognitive function measures in a defined population of community-dwelling elders. *Annuals of Epidemiology, 1*, 215-230. doi: 10.1016/1047-2797(91)90001-S

Craik, F. I. M. (2007). The role of cognition in age-related hearing loss. *Journal of the American Academy of Audiology, 18*, 539-547. Retrieved from http://www.audiology.org/resources/journal/Pages/default.aspx. doi: 10.3766/jaaa.18.7.2

Craik, F. I. M., & McDowd, J. M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*(3), 474-479. doi: 10.1037/0278-7393.13.3.474

Craik, F. I. M., Winocur, G., Palmer, H., Binns, M. A., Edwards, M., Bridges, K., . . . Stuss, D. T. (2007). Cognitive rehabilitation in the elderly: effects on memory. *Journal of the International Neuropsychological Society, 13*(1), 132-142.

Dakim Inc. (2002). Fight the threat of dementia with Dakim BrainFitness. Santa Monica, CA.

Dik, M., Deeg, D. J., Visser, M., & Jonker, C. (2003). Early life physical activity and cognition at old age. *Journal of Clinical and Experimental Neuropsychology, 25*(5), 643-653. doi: 10.1076/jcen.25.5.643.14583

Drag, L. L., & Bieliauskas, L. A. (2010). Contemporary review 2009: Cognitive aging. *Journal of Geriatric Psychiatry and Neurology, 23*(2), 75-93. doi: 10.1177/0891988709358590

Duff, K., Beglinger, L. J., Moser, D. J., Schultz, S. K., & Paulsen, J. S. (2010). Practice effects and outcome of cognitive training: Preliminary evidence from a memory training course. *American Journal of Geriatric Psychiatry, 18*(1). doi: 10.1097/JGP.0b013e3181b7ef58

Edwards, J. D., Wadley, V. G., Vance, D. E., Wood, K. M., Roenker, D. L., & Ball, K. K. (2005). The impact of speed of processing training on cognitive and everyday performance. *Aging & Mental Health and Society, 9*, 262-271. doi: http://psychsocgerontology.oxfordjournals.org/content/early/recent

Engvig, A., Fjell, A. M., Westlye, L. T., Moberget, T., Sundseth, O., Larsen, V. A., & Walhovd, K. B. (2010). Effects of memory training on cortical thickness in the elderly. *Neuroimage, 52*, 1667-1676. doi: 10.1016/j.neuroimage.2010.05.041

Fabrigoule, C., Letenneur, L., Dartigues, J., Zarrouk, M., Commenges, D., & Barberger-Gateau, P. (1995). Social and leisure activities and risk of dementia: A prospective longitudinal study. *Journal of the American Geriatrics Society, 43*(5), 485-490. Retrieved from http://www.nejm.org/.

Floyd, M., & Scogin, F. (1997). Effects of memory training on the subjective memory functioning and mental health of older adults: A meta-analysis. *Psychology and Aging, 12*, 150-161.

Folstein, M. F., Folstein, S. E., & McHugh, P. R. (1975). “Mini-mental state”: A practical method for grading the cognitive state of patients for the clinician. *Journal of Psychiatric Research, 12*(3), 189-198. doi: 10.1016/0022-3956(75)90026-6

Fratiglioni, L., Paillard-Borg, S., & Winblad, B. (2004). An active and socially integrated lifestyle in late life might protect against dementia. *The Lancet: Neurology, 3*, 343-353. doi: 10.1016/S1474-4422(04)00767-7

Fried, L. P., Carlson, M. C., Freedman, M., Frick, K. D., Glass, T. A., Hill, J. M., S., . . . Zeger, S. (2004). A social model for health promotion for an aging population: initial evidence on the Experience Corps model. *Journal of Urban Health, 81*(1), 64-78. doi: 10.1093/jurban/jth094

Glisky, E. L. (2007). Changes in Cognitive Function in Human Aging. In D. R. Riddle (Ed.), *Brain Aging: Models, Methods, and Mechanisms.* (pp. 3-20). Boca Raton: CRC Press of the Taylor & Francis Group, LLC.

Gunther, V. K., Schafer, P., Holzner, B. J., & Kemmler, G. W. (2003). Long-term improvements in cognitive performance through computer-assisted cognitive training: A pilot study in a residential home for older adults. *Aging & Mental Health, 7*(3), 200-206. doi: 10.1080/1360786031000101175

Hall, C. B., Lipton, R. B., Sliwinski, M., Katz, M. J., Derby, C. A., & Verghese, J. (2009). Cognitive activities delay onset of memory decline in persons who develop dementia. *Neurology, 73*, 356-361. doi: http://www.neurology.org/

Head, D., Rodrigue, K. M., Kennedy, K. M., & Raz, N. (2008). Neuroanatomical and cognitive mediators of age-related differences in episodic memory. *Neuropsychology, 22*(4), 491-507. doi: 10.1037/0894-4105.22.4.491

Hertzog, C., Kramer, A. F., Wilson, R. S., & Lindenberger, U. (2009). Enrichment effects on adult cognitive development. Can the functional capacity of older adults be preserved and enhanced? [monograph]. *Psychological Sciences in the Public Interest, 9*(1), 1-65. doi: 10.1111/j.1539-6053.2009.01034.x

Larrabee, G., & Crook, T. (1989). Dimensions of everyday memory in age-associated memory impairment. *Psychological Assessment: A Journal of*

Consulting and Clinical Psychology, 1(2), 92-97. doi: 10.1037/1040-3590.1.2.92

Levine, B., Stuss, D. T., Winocur, G. B., M.A., Fahy, L., Mandic, M., & Bridges, K. R., I.H. (2007). Cognitive rehabilitation in the elderly: effects on strategic behavior in relation to goal management. *Journal of the International Neuropsychological Society, 13*(1), 143-152. doi: http://dx.doi.org/10.1017/S1355617707070178

Li, S. C., Schmiedek, F., Huxhold, O., Rocke, C., Smith, J., & Lindenberger, U. (2008). Working memory plasticity in old age: Practice gain, transfer, and maintenance. *Psychology and Aging, 23*(4), 731-742. doi: 10.1037/a0014343

Lichtenberger, E. O., Kaufman, A. S., & Lai, Z. C. (2002). Overview *Essentials: WMS-III Assessments* (pp. 1-15). New York: John Wiley & Sons, Inc.

Lövdén, M., Bäckman, L., Lindenberger, U., Schaefer, S., & Schmiedek, F. (2010). A theoretical framework for the study of adult cognitive plasticity. *Psychological Bulletin, 136*, 659-676. doi: 10.1037/a0020080

Lustig, C., & Flegal, K. E. (2008). Targeting latent function: Encouraging effective encoding for successful memory training and transfer. *Psychology and Aging, 23*(4), 754-764. doi: 10.1037/a0014295

Mahncke, H. W., Connor, B. B., Appelman, J., Ahsanuddin, O. N., Hardy, J. L., Wood, R. A., . . . Merzenich, M. M. (2006). Memory enhancement in healthy older adults using a brain plasticity-based training program: A randomized, controlled study. *The National Academy of Sciences of the USA, 103*(33), 12523-12528. doi: 10.1073/pnas.0605194103

McDonald-Miszczak, L. A., Hertzog, C., & Hultsch, D. F. (1995). Stability and accuracy of metamemory in adulthood and aging: A longitudinal analysis. *Psychology and Aging, 10*, 553-564. doi: 10.1037/0882-7974.10.4.553

McKoon, G., Ratcliff, R., & Dell, G. S. (1986). A critical evaluation of the semantic-episodic distinction. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*(2), 295-306. Retrieved from http://www.apa.org/pubs/journals/xlm/index.aspx.

Miller, K., Siddarth, P., E., O. T., Kim, J., Lea, J., Wong, J., & Small, G. W. (2010). *Dakim's Brain Fitness: A Computerized Cognitive Training Program for Older Adults*. Paper presented at the Annual Meeting of the American Association for Geriatric Psychiatry (AAGP), Savannah, GA.

Mitchell, D. B., & Bruss, P. J. (2003). Age differences in implicit memory: Conceptual, perceptual, or methodological? *Psychology and Aging, 18*(4), 807-822. doi: 10.1037/0882-7974.18.4.807

Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., . . . Chertkow, H. (2005). The Montreal Cognitive Assessment (MoCA): A Brief Screening Tool For Mild Cognitive Impairment. *Journal of the American Geriatrics Society, 53*, 695-699. doi: 10.1111/j.1532-5415.2005.53221.x

Nyberg, L., Bäckman, L., Erngrund, K., Olofsson, U., & Nilsson, L. G. (1996). Age differences in episodic memory, semantic memory, and priming:

relationships to demographic, intellectual, and biological factors. *Journal of Gerontology: Psychological Sciences, 51*(4), P234-P240. Retrieved from www.psychsocgerontology.oxfordjournals.org.

Old, S. R., & Naveh-Benjamin, M. (2008). Age-related changes in memory: Experimental approaches. In S. M. Hofer & D. F. Alwin (Eds.), *Handbook of Cognitive Aging: Interdisciplinary Perspectives* (pp. 151-167). Thousand Oaks, CA: Sage Publications, Inc.

Papp, K. V., Walsh, S. J., & Snyder, P. J. (2009). Immediate and delayed effects of cognitive interventions in healthy elderly: A review of current literature and future directions. *Alzheimer's & Dementia, 5*, 50-60. doi: 10.1016/j.jalz.2008.10.008

Park, D. C., Lautenschlager, G., Hedden, T., Davidson, N. S., Smith, A. D., & Smith, P. K. (2002). Models of visuospatial and verbal memory across the adult life span. *Psychology and Aging, 17*(2), 299-320. doi: 10.1037/0882-7974.17.2.299

Park, D. C., & Shaw, R. J. (1992). Effect of Environmental Support on Implicit and Explicit Memory in Younger and Older Adults. *Psychology and Aging, 7*(4), 632-642. doi: 10.1037/0882-7974.7.4.632

Penrod, J. (1979). Talker effects of word-discrimination scores of adults with sensorineural hearing impairment. *Journal of Speech and Hearing Disorders, 44*, 340-349. Retrieved from http://www.biomedsearch.com/nih/Talker-effects-word-discrimination-scores/480938.html.

Podewils, L. J., Guallar, E., Kuller, L. H., Fried, L. P., Lopez, O., Carlson, M., & Lyketsos, C. G. (2005). Physical activity, APOE genotype, and dementia risk: Findings from the Cardiovascular Health Cognition Study *American Journal of Epidemiology, 161*(7), 639-651. doi: 10.1093/aje/kwi092

Rasmusson, D. X., Rebok, G. W., Bylsma, F. W., & Brandt, J. (1999). Effects of three types of memory training in normal elderly. *Aging, Neuropsychology, and Cognition, 6*(1), 56-66. doi: 10.1076/anec.6.1.56.790

Rebok, G. W., Carlson, M. C., & Langbaum, J. B. S. (2007). Training and maintaining memory abilities in healthy older adults: Traditional and novel approaches. *Journals of Gerontology. Series B, Psychological Sciences and Social Sciences, 62B*(Special Issue I), 53-61. Retrieved from http://psychsocgerontology.oxfordjournals.org/content/early/recent.

Rebok, G. W., Rasmusson, D., & Brandt, J. (1996). Prospects for computerized memory training in normal elderly: Effects of practice on explicit and implicit memory tasks. *Applied Cognitive Psychology, 10*(3), 211-223. doi: 10.1002/(SICI)1099-0720(199606)10:3<211::AID-ACP375>3.0.CO;2-C

Rebok, G. W., Rasmusson, D., Bylsma, F., & Brandt, J. (1997). Memory improvement tapes: How effective for elderly adults? *Aging, Neuropsychology, and Cognition, 4*(4), 304-311. doi: 10.1080/13825589708256655

Roediger, H. L. (1990). Implicit memory- retention without remembering. *American Psychologist, 45*(9), 1043-1056. doi: 10.1037/0003-066X.45.9.1043

Roeser, R. J., & Clark, J. L. (2008). Live voice speech recognition audiometry- Stop the madness! *Audiology Today, 20*(1), 32-33. Retrieved from http://www.audiology.org/Pages/default.aspx.

Ronnlund, M., Nyberg, L., Bäckman, L., & Nilson, L.-G. (2005). Stability, growth, and decline in adult lifespan development of declarative memory: Cross-sectional and longitudinal data from a population-based study. *Psychology and Aging, 20*(1), 3-18. doi: 10.1037/0882-7974.20.1.3

Salthouse, T. A. (1994). The aging of working memory. *Neuropsychology, 8*(4), 535-543. Retrieved from http://www.apa.org/pubs/journals/neu/.

Scarmeas, N., Levy, G., Tang, M., Manly, J., & Stern, Y. (2001). Influence of leisure activity on the incidence of Alzheimer's disease. *Neurology, 57*, 2236-2242. Retrieved from http://www.neurology.org/.

Schacter, D. L. (1987). Implicit memory- history and current status. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 12*(3), 501-518. Retrieved from http://www.apa.org/pubs/journals/xlm/.

Schieber, F. (2002). Human Factors and Aging:Identifying and Compensating for Age-related Deficits in Sensory and Cognitive Function. In N. Charness & K. W. Schaie (Eds.), *Impact of technology on successful aging* (pp. 42-84). New York: Springer.

Seagull, B., & Seagull, S. (2007). *Mind Your Mind*. Verona, Wisconsin: Attainment Company.

Smith, G. E., Housen, P., Yeffe, K., Ruff, R., Kennison, R. K., Mahncke, H. W., & Zelinski, E. M. (2009). A cognitive training program based on principles of brain plasticity: Results from the Improvement in Memory with Plasticity-based Adaptive Cognitive Training (IMPACT) Study *Journal of the American Geriatrics Society, 57*(4), 594-603. doi: 10.1111/j.1532-5415.2008.02167.x

Spaniol, J., Madden, D. J., & Voss, A. (2006). A diffusion model analysis of adult age differences in episodic and semantic long-term memory retrieval. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 32*(1), 101-117. doi: 10.1037/0278-7393.32.1.101

Spreen, O., & Strauss, E. (1991). *A compendium of neuropsychological tests: Administration, norms and commentary*. New York, Oxford: Oxford University Press.

Stiles, J. (2000). Neural Plasticity and Cognitive Development. *Developmental Neuropsychology, 18*(2), 237-272. Retrieved from http://www.tandfonline.com/toc/hdvn220/current.

Stine-Morrow, E. A. L., & Miller, L. M. S. (1999). Basic Cognitive Processes. In J. C. Cavanaugh & S. C. Whitbourne (Eds.), *Gerontology: An Interdisciplinary Perspective* (pp. 186-212). New York: Oxford University Press.

Stine-Morrow, E. A. L., Parisi, J. M., Morrow, D., & Park, D. (2008). The effects of an engaged lifestyle on cognitive vitality: A field experiment. *Psychology and Aging, 23*(4), 778-786. doi: 10.1037/a0014341

Stine-Morrow, E. A. L., Parisi, J. M., & Morrow, D. G. P., D.C. (2008). The effects of an engaged lifestyle on cognitive vitality: A field experiment. *Psychology and Aging, 23*(4), 778-786. doi: 10.1037/a0014341

Stuss, D. T., Robertson, I. H., Craik, F. I. M., Levine, B., Alexander, M. P., Black, S. D., D., . . . Winocur, G. (2007). Cognitive rehabilitation in the elderly: a randomized trial to evaluate a new protocol. *Journal of the International Neuropsychological Society, 13*(1), 120-131. doi: 10.1017/S1355617707070154

Tabachnick, B. G., & Fidell, L. S. (1996). Review of univariate and bivariate statistics. In S. Hartman (Ed.), *Using Multivariate Statistics* (Fifth ed., pp. 33-59). Boston: Pearson Education, Inc.

Tulving, E. (1983). *Elements of episodic memory*. Oxford: Oxford University press.

Tulving, E. (1993). What is episodic memory? *Current Directions in Psychological Science, 2*(3), 67-70.

Valenzuela, M., & Sachdev, P. (2009). Can cognitive exercise prevent the onset of dementia? Systematic review of randomized clinical trials with longitudinal follow-up. *American Journal of Geriatric Psychiatry, 17*(3), 179-187. doi: 10.1097/JGP.0b013e3181953b57

Verghese, J., Lipton, R. B., Katz, M. J., Hall, C. B., Derby, C. A., Kuslansky, G., . . . Buschke, H. (2003). Leisure activities and the risk of dementia in the elderly. *New England Journal of Medicine, 348*(25), 2508-2516. doi: 10.1056/NEJMoa022252

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging, 7*(2), 242-251. doi: 10.1037/0882-7974.7.2.242

Wang, H., Karp, A., Winblad, B., & Fratiglioni, L. (2002). Late-life engagement in social and leisure activities is associated with a decreased risk of dementia: A longitudinal study from the Kungsholmen Project. *American Journal of Epidemiology, 155*(12), 1081-1087. doi: 10.1093/aje/155.12.1081

Wechsler, D. (1997). *WAIS-III/WMS-III technical manual*. San Antonio, TX: The Psychological Corporation.

Weiten, W. (2004). *Psychology: Themes and Variations* (sixth ed.). Belmont, CA: Wadsworth/Thomson Learning, Inc.

Weuve, J., Kang, J. H., Manson, J. E., Breteler, M. M., Ware, J. H., & Grodstein, F. (2004). Physical activity, including walking, and cognitive function in older women. *Journal of the American Medical Association, 292*, 1454-1461. doi: 10.1001/jama.292.12.1454

Wilson, K. Y. (2005). *The effectiveness of memory training programs in improving the subjective memory characteristics of healthy older adults with memory complaints: A meta-analysis.* Doctorate in Psychology, Marshall University, Huntington, West Virginia. (3278573)

Zacks, R. T., Hasher, L., & Li, K. Z. H. (2000). Human memory. In F. I. M. Craik & T. A. Salthouse (Eds.), *The Handbook of Aging and Cognition* (Second ed., pp. 293-357). Erlbaum, Mahwah, NJ Lawrence Erlbaum Associates, Inc.

Zelinski, E. M., & Burnight, K. P. (1997). Sixteen-year longitudinal and time lag changes in memory and cognition in older adults. *Psychology and Aging, 12*(3), 503-513. doi: 10.1037/0882-7974.12.3.503

Appendix: Institutional Review Board (IRB) Study Approval

USF
UNIVERSITY OF SOUTH FLORIDA

DIVISION OF RESEARCH INTEGRITY AND COMPLIANCE
Institutional Review Boards, FWA No. 00001669
12901 Bruce B. Downs Blvd., MDC035 • Tampa, FL 33612-4799
(813) 974-5638 • FAX (813) 974-5618

February 16, 2009

Elizabeth Gagnon, BA
College of Behavioral and Community Sciences
MHC 1300

RE: **Expedited Approval** for Initial Review
IRB#: 107623 I
Title: *Dakim Mpower Memory Training*
Study Approval Period: 02/13/2009 to 02/12/2010

Dear Ms. Gagnon:

On February 13, 2009, Institutional Review Board (IRB) reviewed and **APPROVED** the above protocol **for the period indicated above.** It was the determination of the IRB that your study qualified for expedited review based on the federal expedited category number seven (7).

Approval included with the Adult Minimal Risk Informed Consent form.

Please note, if applicable, the **enclosed informed consent/assent documents are valid during the period indicated by the official, IRB-Approval stamp located on page one of the form.** Valid consent must be documented on a copy of the most recently IRB-approved consent form. Make copies from the enclosed original.

Please reference the above IRB protocol number in all correspondence regarding this protocol with the IRB or the Division of Research Integrity and Compliance. In addition, we have enclosed an Institutional Review Board (IRB) Quick Reference Guide providing guidelines and resources to assist you in meeting your responsibilities in the conduction of human participant research. Please read this guide carefully. It is your responsibility to conduct this study in accordance with IRB policies and procedures and as approved by the IRB.

We appreciate your dedication to the ethical conduct of human subject research at the University of South Florida and your continued commitment to human research protections. If you have any questions regarding this matter, please call 813-974-9343.

Sincerely,

Krista Kutash, Ph.D., Chairperson
USF Institutional Review Board

Enclosures: (If applicable) IRB-Approved, Stamped Informed Consent/Assent Documents(s)

Cc: Various Menzel/cd, USF IRB Professional Staff
Jerri Edwards, PhD

SB-IRB-Approved-EXPEDITED-0801