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Addressing Cognitive Decline: Evaluating the Effects of a Cognitive Training Program for Individuals with Mild to Moderate Cognitive Impairment

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Abstract

Cognitive training offers a nonpharmacological method for increasing or stabilizing cognitive functioning through the use of guided practice on a set of tasks designed to reflect particular cognitive functions, such as memory, attention, language, or executive function. The purpose of the current study was to evaluate the efficacy of a cognitive training program for individuals with mild to moderate cognitive impairment. Six participants who displayed mild to moderate cognitive impairment were recruited at a local care facility and participated in a cognitive training program that consisted of 24 sessions conducted over 12 weeks. At the request of the facility's activities staff, the program was repeated in its entirety a second time. Thus, participants were evaluated with a battery of neuropsychological assessments in a pre-post-secondary-post manner. Effect size data indicates that the cognitive training program offers promise for improvement or stabilization on a number of cognitive domains, although patterns are variable. Results of this study suggest that this cognitive training program may be a useful tool for individuals with mild cognitive impairment.

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Introduction

With aging comes a variety of changes to an individual's life. In some cases, aging has a minimal effect on the cognitive abilities of a person, while in others, including various forms of dementia, cognition is highly impacted. These changes in cognition have innumerable effects on the lives of the individual affected as well as their families. Currently, no interventions exist to stop or even slow most causes of cognitive decline. Cognitive training may provide one possible avenue for addressing the issue of cognitive impairment.

Cognitive Impairment

In their 2011 Call for Action, the Centers for Disease Control defines cognitive impairment as "when a person has trouble remembering, learning new things, concentrating, or making decisions that affect their everyday life." While this is a useful explanation for broadly understanding how cognitive impairment manifest itself, the American Psychiatric Association further details the concept of cognitive impairment. The Fifth Edition of the Diagnostic and Statistical Manual (DSM-5; 2013) lists six cognitive domains that can be affected when an individual experiences cognitive impairment.

The first domain the DSM-5 addresses is that of complex attention. Complex attention includes sustained, selective, and divided attention, as well as processing speed. Sustained attention is the maintenance of attention over time, while selective attention is the maintenance of attention despite competing distractions. The ability to attend to two tasks within the same time period is known as divided attention, and processing speed is the amount of time an individual requires to understand information. Individuals with impairment in complex attention may have difficulty focusing on one task for a long period of time, or may struggle in environments with multiple stimuli. It may also take them longer to understand tasks or to complete them.

Second, the domain of language and memory includes immediate or recent memory, as well as very-long-term memory of autobiographical data and semantic memory. Impairment in this area generally affects immediate and recent memory, making it difficult for individuals to retain new information. Compared with recent memory, very-long-term memory remains much more intact (the exception being in cases of very severe neurocognitive disorders).

The third cognitive domain is language, which includes both expressive and receptive language. Expressive language is the ability to produce words as well as proper grammar and syntax. An individual with impairment in this area may have difficulty finding words, names, or specific terms, while an individual struggling with receptive language will have difficulty comprehending what is being communicated.

Perceptual-motor deficits comprise the DSM-5's fourth cognitive domain. This includes visual perception: facial recognition or matching figures; visuoconstruction: assembly of items requiring hand-eye coordination like drawing or copying; perceptual-motor: integration of perception with purposeful movement, such as inserting pegs into a slotted board; praxis: integrity of learned movements including imitation and pantomime; and gnosis abilities: including perceptual integrity of awareness and recognition, such as recognizing faces and colors. Individuals with impairment in these areas may often find themselves lost, may struggle with using tools or other crafting tasks, as well as recognition of faces and colors.

The fifth cognitive domain described is executive function. Executive function refers to higher-order thinking skills, such as planning, decision making, working memory, error correction, inhibition, and mental flexibility. Impairment in this area may cause difficulty completing projects, planning ahead, multitasking, or making decisions.

Finally, social cognition includes emotional recognition, the ability to identify emotion in others, and theory of mind, the ability to consider another person's mental state or experience. Impairment in this area may result in odd or inappropriate social behavior, with the individual possessing little insight into social cues.

However, not all individuals experiencing changes in cognition are necessarily experiencing cognitive impairment. There are differing degrees of cognitive decline, with the severity of impairment occurring on a continuum. Throughout the process of aging, individuals may progress along this continuum, showing greater impairment in cognitive and behavioral functioning over time to the point where daily functioning may be significantly diminished.

Normal Aging

As individuals age, natural changes in cognitive abilities occur. This is known as age-associated cognitive decline, in which decreases in cognitive abilities are expected but are non-pathological (Dreary et al., 2009). Areas such as processing speed, executive function, and complex attention may decline with normal aging. In addition, some forms of language and memory tend to be effected by aging as well (Salthouse 1996; Craik & Salthouse, 2008; Dreary et al., 2009; Harada et al., 2013).

Processing speed is one of the first domains to change within age-associated cognitive decline, beginning to decline in the third decade of life and continuing throughout the lifespan (Harada et al., 2013). Generally, this is an overall slowing of the efficiency with which one processes information, as older adults are likely to take longer to comprehend and respond to stimuli when compared with younger adults (Salthouse, 1996; Craik & Salthouse, 2008). This has been further demonstrated with regard to reaction time given that reaction time continues to increase throughout adulthood, which provides evidence that processing speed is slowing (Whitbourne & Whitbourne, 2014). This overall slowing can permeate to affect performance in other cognitive domains as well (e.g., verbal fluency), so a decline in processing speed can have implications for functioning in other domains as an individual ages (Harada et al., 2013).

Attention and executive function are two such domains that show a general decline in efficiency. Older adults tend to perform worse than younger adults on tasks involving working memory, selective attention, and divided attention (Craik & Salthouse, 2008; Harada et al., 2013). These skills can overlap with executive functioning tasks, such as being able to shift attention and use inhibitory control (i.e., turning off one response while performing another; Whitbourne & Whitbourne, 2014). Furthermore, executive abilities that require a timed motor component are particularly susceptible to age effects, as well as reasoning with unfamiliar material and mental flexibility.

However, executive functions such as understanding similarities, descriptions, and reasoning with familiar material tend to remain stable (Harada et al., 2013).

In the realm of language, most abilities remain relatively unaffected by aging. Vocabulary and syntax persist, and oftentimes vocabulary continues to improve with normal aging. The areas of language that tend to decline with aging include visual confrontation naming (i.e., the ability to see a common object and name it) and verbal fluency (i.e., the ability to perform a word search and generate words for a certain category). As with the declines seen in processing speed as one ages, the areas of decline within language generally show a slowing of these abilities rather than a complete loss of function, so the impact of these declines on an individual's daily functioning tends to be minimal (Harada et al., 2013).

Concerning memory functioning, with age-associated cognitive decline it is typical to observe reductions in recall (i.e., spontaneous retrieval of information from memory without a cue), source memory (i.e., knowing the source of learned information), prospective memory (i.e., remembering to perform intended actions in the future), and episodic memory (i.e., remembering events from years ago; Harada et al., 2013; Whitbourne & Whitbourne, 2014). Generally, this decline is observed as a slowing of efficiency or requiring more effort in these areas and are not necessarily indicative of an underlying pathology (Craik & Salthouse, 2008). However, experiencing changes in other forms of memory should be noted. Typically, procedural memory (i.e., performing tasks), and semantic recall (i.e., general knowledge) remain intact with normal aging (Harada et al., 2013; Whitbourne & Whitbourne, 2014). Deficits in these areas should be of concern and likely indicate a progressed form of dementia or other neurocognitive disorder.

In summary, age-associated cognitive decline is not necessarily indicative of an impending cognitive disorder or disease process. Rather, this type of cognitive decline is often a slowing in efficiency of specific cognitive domains compared to younger adults and does not negatively impact daily functioning (Craik & Salthouse, 2008; Harada et al., 2013, Whitbourne & Whitbourne, 2014). More severe declines in above-mentioned abilities or declines outside of these specified areas may indicate progression to a further degree of cognitive impairment.

Cognitive Decline without Dementia

The next level of cognitive decline is defined as a change in cognition that is noticeable by others familiar with the individual, but is not severe enough to meet the criteria necessary for a diagnosis of dementia (or a diagnosis of a neurocognitive disorder, as defined by the DSM-5). This can manifest as an isolated deficit in memory, or across several cognitive domains, but is beyond the general slowing with age (Lyketsos, 2002). Cognitive impairment that does not reach the threshold for dementia is estimated to affect about 22% (5.4 million) of individuals in the United States age 71 years or older (Plassman et al., 2008). Despite the lack of severity to warrant a diagnosis, this type of cognitive decline contributes to decreased quality of life, increased neuropsychiatric symptoms, as well as increased disability and health care costs (Lyketsos, 2002). Furthermore, this type of cognitive impairment is a risk factor for dementia, with progression rates between 6 to 25% per year compared with 0.2 to 3.9%%

among cognitively healthy older adults (Petersen et al., 2001). Plassman and colleagues (2008) found this progression rate to center at 12%, and additionally found that about 8% of those experiencing cognitive decline without dementia die annually. As this level of cognitive decline is highly prevalent and has a progressive nature for many individuals, interventions addressing decline at this stage are needed.

Neurocognitive Disorder

The recent publication of the DSM-5 has largely moved away from the term "dementia" and instead substituted the term neurocognitive disorder (NCD). This change is intended to be more inclusive to younger individuals experiencing impairment due to traumatic brain injury and individuals with a substantial decline in a single cognitive domain, rather than the typical older adult who is diagnosed with dementia. However, the term dementia remains widely-understood and is still frequently used in the literature as well as in health care settings.

Another change to the classification within the DSM-5 includes the further breakdown of the NCD diagnosis into minor and major NCD. With a diagnosis of minor NCD, there is a noticeable decline in cognitive functioning from previous levels, but the individual is still capable of completing activities of daily living on their own or with a minimal degree of support. NCDs are often diagnosed through the use of neuropsychological testing, with mild NCDs being indicated by performance falling one to two standard deviations below means based on normative data (American Psychiatric Association, 2013).

With major NCD, again there is a noticeable decline in cognitive functioning from previous levels, although in this case the decline is more severe in that individuals with major NCDs have scores falling two or more standard deviations below the mean on neuropsychological tests (American Psychiatric Association, 2013). Additionally, the individual can no longer complete activities of daily living without substantial support. For instance, tasks such as paying bills or taxes, managing medication, driving, or feeding and cleaning oneself may become too difficult for the individual to complete independently.

To further address the movement away from the diagnosis of dementia, the new diagnosis of NCD includes subtypes of NCDs based on etiological or pathological specifications. For instance, a diagnosis of Mild NCD Due to Alzheimer's Disease requires: evidence of Alzheimer's genetic mutation; clear evidence of decline in memory and at least one other cognitive domain; a gradual decline in cognition; and no evidence of other neurodegenerative disorders. Other subtypes of NCDs included in the DSM-5 that are recognized forms of dementia include Major or Mild Frontotemporal NCD, Major or Mild NCD with Lewy Bodies, and Major or Mild Vascular NCD (American Psychiatric Association, 2013). Alzheimer's disease is the most prevalent of these causes, accounting for an estimated 60 percent to 80 percent of all cases of dementia (Alzheimer's Association, 2017).

Interventions for Cognitive Impairment

There is an immense need for interventions to combat cognitive impairment at all levels. The most daunting demand comes from the rising prevalence of Alzheimer's disease (AD). Despite the fact that AD affects 5.5 million Americans, it is the only disease in the top ten leading causes of deaths in the United States that cannot be prevented, slowed or cured (Alzheimer's Association, 2017). This statistic becomes even more staggering when one considers that the population most at risk – adults 65 years or older – is projected to nearly double from 48 million to 88 million by the year 2050 (Alzheimer's Association, 2017). If actions are not taken to address these changes, the prevalence of Alzheimer's will continue to increase, affecting an estimated 14 million of individuals and their families (Alzheimer's Association, 2017). Furthermore, AD will continue to incur a significant cost to society, evidenced as 2017 marks the first year that annual payments caring for individuals living with Alzheimer's or other dementias will surpass a quarter of a trillion dollars (an estimated $259 billion; Alzheimer's Association, 2017).

Currently, the U.S. Food and Drug Administration (FDA) has approved six drugs to alleviate symptoms of Alzheimer's dementia. They are as follows: tacrine, which has since been discontinued in the United States due to potentially severe side effects, galantamine, rivastigmine, donepezil, memantine, and finally a drug that combines memantine and donepezil. These drugs may also be useful for managing other forms of dementia such as vascular cognitive impairment and dementia with Lewy bodies. However, it is essential to note that none of these drugs stop the progression of AD (Alzheimer's Association, 2017).

Furthermore, the future of pharmaceutical success is not particularly bright. Of the drug trials intended to address Alzheimer's between 2002 and 2012, only one compound (memantine) was advanced to the FDA and approved for marketing, indicating an overall success rate for approval at 0.4% (99.6% attrition; Cummings, Morstorf, & Zhong, 2014). Pharmaceutical research is not only expensive, but time consuming, as the drug must pass through multiple phases of clinical trials in order to be approved. Despite much effort, the pharmacological interventions currently available are not sufficient or effective in combatting cognitive decline (Alzheimer's Association, 2017).

Due to the lack of success that pharmaceutical trials have had in addressing cognitive decline, research has begun to consider nonpharmacological interventions as well. Thus far, as with current pharmacological therapies, the course of Alzheimer's disease has not been consistently slowed or altered by nonpharmacological therapies (Alzheimer's Association, 2017). However, one systematic review of randomized control trials employing cognitive stimulation interventions indicated beneficial effects on cognitive function and some aspects of well-being for individuals with a diagnosis of dementia (Aguirre et al., 2013). Cognitive stimulation interventions are based on procedures utilized as part of Reality Orientation (RO) interventions. RO consists of presenting group participants with basic personal and current information, using materials such as individual calendars, word-letter games, building blocks and large piece puzzles to encourage engagement. Additionally, reminders of the name of the location, the day, date, weather, and current events, would be provided (Taulbee & Folsom, 1966). Cognitive stimulation builds upon these principles and is defined as engagement in a range of activities and discussions aimed at general enhancement of cognitive and social functioning (Clare & Woods, 2004). Aguirre and colleagues' 2013 review found that cognitive stimulation provided benefits across several cognitive measures for people with dementia when compared to control groups. Furthermore, the review found that cognitive stimulation benefits participants' self-ratings of well-being and quality of life. These findings provide evidence that nonpharmacological interventions designed to address cognitive functioning may hold promise for addressing cognitive decline.

Cognitive Training

Cognitive training is another such nonpharmacological intervention approach that may be used to combat cognitive decline. Cognitive training is defined as guided practice on a set of standard tasks designed to reflect particular cognitive functions with a range of difficulty levels to suit the individual's level of ability (Clare & Woods, 2004). This is contrasted with the procedures of cognitive stimulation, as described above, and cognitive rehabilitation. Although these terms are often times used interchangeably in the literature, there are important distinctions between the three.

Cognitive stimulation is a much more general process, often focused on reality orientation and group dynamics. For instance, in the review by Aguirre and colleagues discussed above, the terms cognitive stimulation, reality orientation, memory therapy, memory groups, memory support, memory stimulation, global stimulation and cognitive psychostimulation were all used as search criteria. This technique is not particularly structured or standardized, as it can involve a wide range of activities with the general goal of cognitive enhancement. Oppositely, cognitive training targets specific cognitive domains to be enhanced through a series of standardized tasks. While both cognitive stimulation and cognitive training provide a nomothetic approach, cognitive training is delivered in a more structured, targeted, and regulated fashion.

Cognitive rehabilitation, contrarily, is a highly individualized intervention. In cognitive rehabilitation, the individual experiencing cognitive decline or impairment, their family, and their health care providers decide upon very specific goals for the individual (e.g., to remember to take medications or recall the names of family members). Generally, these goals are designed to take advantage of intact areas of cognition in order to compensate for those domains that may be impaired. The emphasis in this technique is on improving performance in everyday life (Clare & Woods, 2004). Compared to cognitive training, cognitive rehabilitation is a much more idiographic approach, and thus is not well-suited to address cognitive decline in multiple individuals, or in the group activities settings often seen in assisted living or memory care facilities.

Due to the frequency with which these terms are used without distinction, the literature that exists on cognitive training as operationally defined above is somewhat limited. Furthermore, several cognitive training programs exist and have substantial support, but the majority of these programs are designed for healthy individuals, rather than those already experiencing cognitive decline (Rebok et al., 2014). Despite these limitations to the literature, cognitive training is thought to be “probably efficacious” in slowing cognitive decline for those with early-stage Alzheimer's disease (Clare & Woods, 2004).

An early examination of the effects of cognitive training for those experiencing cognitive impairment comes from Mate-Kole and colleagues (2007). This study included six older adults with a diagnosis of moderate to severe dementia. These individuals completed a combination of two training programs called "Mind Aerobics" and "Adaptive Computerized Cognitive Training" (ACCT) over a six-week period. Mind Aerobics is an interactive group training seminar, including pen and paper activities as well as other hands-on activities, with a focus on memory, attention, cognitive flexibility, manual dexterity and problem solving. The ACCT program, on the other hand, consisted of a series of computerized tasks. These tasks focused on attention, visual-spatial and motor skills, problem solving, memory and visual discrimination. Participants were assessed with neuropsychological tests prior to and immediately following training. Results showed improvements on measures of overall cognitive function, short-term memory, and activities of daily living, with no significant declines observed on any cognitive measures. Although the study had a small sample size and lack of control group, these results provided evidence that cognitive training may have potential for addressing cognitive decline.

Another study focused on answering the questions regarding carryover effects and the proper "dose" of cognitive training for individuals with mild AD. Kanaan and colleagues (2014) used an intensive cognitive training intervention, delivered over two weeks with four to five hours of training each day, totaling in 40-50 hours of cognitive training per participant. The cognitive training intervention included computer-based exercises as well as paper and pencil tasks. Computerized training targeted working memory, sustained attention, switching attention, and divided attention, while paper and pencil tasks were directed at planning, memory, visual-spatial processing, sustained attention, and selective attention. Despite the intense method of delivery, the training was found to be feasible. Furthermore, participants showed improvements in practiced tasks, and even modest benefits in unpracticed tasks, suggesting that training may generalize to other cognitive domains. This provides further evidence for the effectiveness of cognitive training in individuals with cognitive impairment.

A meta-analysis completed by Bahar-Fuchs, Clare, and Woods (2013) provides a useful summary of the cognitive training literature for individuals experiencing mild to moderate cognitive impairment thus far. Only eleven randomized controlled trials using cognitive training (as operationally defined above) were found, and meta-analysis revealed no positive or negative effects of cognitive training in relation to any reported outcomes. However, the majority of the studies included were found to be of low to moderate quality, stemming from significant risks of bias. Specifically, the authors cite insufficient detail regarding the method used to generate a random group allocation sequence, as well as a lack of concealment of this sequence in attempts to blind participants, researchers or both to group allocation. Additionally, there is concern that the outcome measures used across studies lack uniformity, and further that only cognitive rather than noncognitive measures tend to be used. The authors call for an increase in high-quality trials of cognitive training in order to establish the true efficacy of the intervention for those with cognitive impairment.

Purpose of the Current Study

The purpose of the current study was to add to the literature regarding cognitive training through the evaluation of a cognitive training program for individuals with mild to moderate cognitive impairment. As the program is designed to address specific cognitive domains, it was hypothesized that mild improvement or stability would be found in each domain following completion of the cognitive training course. In addition, the effects of the cognitive training program on the experience of depressive symptoms and memory self-efficacy were assessed. Based on previous literature, modest decline in depression and improvements in memory self-efficacy were expected (Mate-Kole et al., 2007).

Method

Setting

Participants were recruited from a facility in a small Midwestern city. The facility was a convent that contained a "health care unit" that provided assisted living and memory care services to elderly nuns. Both the cognitive training courses and assessments were completed at this facility.

Participants

Participants were recruited by asking the activity director at the facility to identify residents who displayed indications of or reported complaints of mild cognitive impairment in their daily lives. For instance, individuals who frequently missed appointments or required assistance in completing daily tasks might be identified and invited to participate. Informed consent was gathered from legal guardians and assent was gathered from participants prior to assessment.

Potential participants were screened with the Modified Mini-Mental Status Exam (3MS; Teng, 1987) to identify individuals in the range of mild to moderate cognitive impairment. Individuals who scored between 60-80 on the 3MS were selected to participate in the cognitive training course. This selected range includes the upper end of the “moderately” impaired range of scores defined by the 3MS, which ranges from scores of 48-77 out of the possible 100. The selected scores for inclusion criteria also extended slightly above the 3MS’s cutoff to include individuals experiencing mild symptoms of cognitive decline as well. Furthermore, this inclusion criteria was also selected based on past research with a cognitive training program designed for individuals experiencing cognitive impairment of greater severity than participants needed for the current study. Participants in that study who scored above 60 on the 3MS tended to find the activities within that program too simple, indicating they might be better suited for courses addressing a mild-to-moderate level of impairment that are more challenging (Johnson, Kennedy & Buchanan, in progress).

Individuals who scored higher or lower than the cutoff scores of 60-80 were excluded, as well as any participants with physical or sensory ailments that would interfere with completion of the training course. A total of six participants completed the first cycle of the cognitive training course, with a mean 3MS score of 73.17 (SD=4.31). All participants were white females with an average age of 87.33 years (SD=5.82). Two participants completed some college, while the remaining four completed a four-year degree or above.

Four of these six participants completed the cognitive training course a second time in its entirety. One participant elected not to complete the second course of training, while the second participant passed away after completing the first course. Approximately two to three weeks passed between the conclusion of the first course and the commencement of the second.

Materials

A brief battery of neuropsychological assessments was used to assess participants prior to and following the cognitive training class. The battery was designed to assess six cognitive domains that were to be targeted through the cognitive training program. These included attention, language, executive functioning, visual spatial skills, verbal memory, and visual memory. Self-report scales assessing memory and depressive symptoms were also completed.

Modified Mini-Mental Status Exam (3MS)

As described above, the 3MS was used as selection criteria for individuals who displayed mild to moderate cognitive impairment, including those who scored between 60-80. The 3MS provides a measure of global cognitive functioning and was administered a second time following completion of the cognitive training program. The 3MS is a standardized, widely used assessment in evaluating individuals with cognitive impairment. It has been shown to be highly reliable for assessing individuals with dementia (Cronbach's alpha = .88), as well as sensitive to differentiating between those with dementia and those without (Tombaugh et al, 1996).

Forward and Backward Digit Span

This test assesses simple attention by requiring participants to listen to and repeat back a sequence of digits. In the forward portion, participants are read a list of numbers and asked to repeat them back exactly as heard, while in the backward portion, participants are read a list of numbers and asked to repeat them back in reverse order. This subtest is included as part of the Working Memory Index within the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechlser, 2008). Both portions of this test correlate highly with the WAIS-III digit span and other measures of attention (Wechsler, 2008).

Brief Test of Attention (BTA)

The BTA assess complex attention through the presentation of a list of numbers and letters (Schretlen, 1997). Participants listen to a recording of a female voice reading the list of numbers and letters aloud and are asked to remember only how many numbers are presented in the list. The second half of the test follows this same format, but participants are instructed to remember only how many letters are presented. Psychometric analysis shows strong internal consistency (α = .82-.91), as well as a strong correlation with other widely used measures of attention, and no practice or interference effects (Schretlen, 1996).

Controlled Oral Word Association Test (COWAT)

The COWAT is a test of language and verbal fluency. In this test, the participant is given a letter and instructed to name as many different words beginning with that letter as they can in one minute. This is then repeated with a second letter. Proper nouns and words with similar endings (bed, beds, bedding) are not included. Language errors of perseverations and intrusions are also measured. The COWAT has high reliability, test-retest validity, and correlates with other neuropsychological tests (Benton & Hamsher, 1989; Ruff et al., 1996).

Trail Making Test Part A and B

Trail Making Test Part A and B is a widely used neuropsychological instrument, providing information on processing speed, mental flexibility, and executive functions. In Part A, participants are given a sheet of paper with the numbers 1-25 contained in circles spread in an array over the page. The participant is asked to use a pencil to connect the circles in order as quickly as possible, beginning at 1 and ending at 25. Part B is similar, however, instead of an array of only numbers, letters are included as well. Participants are asked to "draw a line from 1 to A, A to 2, 2 to B, and so on as quickly as you can until you reach the end." This test has been found to be sensitive in detecting brain damage and cognitive impairment, as well as useful in assessing individuals referred for dementia evaluations (Reitan & Davidson, 1974; Ashendorf et al., 2008).

Visual Puzzles

This test assesses visual spatial reasoning, whole part integration, and mental rotation. The participant is presented with a completed puzzle and asked to identify which three of six picture choices can be put together to make the image. This subtest is included as part of the Perceptual Reasoning Index within the Wechsler Adult Intelligence Scale-Fourth Edition (WAIS-IV; Wechlser, 2008).

Hopkins Verbal Learning Test – Revised (HVLT-R)

The HVLT-R's provides a measure of verbal memory (Brandt & Benedict, 2001). In this test, a participant is read a list of words and then is asked to repeat as many of the words back as they can recall. This list is read three separate times to assess immediate recall and learning abilities. The participant is also asked to provide any words they can recall 20-25 minutes after the three original trials, providing a measure of delayed verbal recall. Finally, the participant is read another, longer list of words and asked to identify if each word was present on the original list. This portion of the test provides a measure of verbal recognition. This test correlates strongly with other tests of verbal memory and has a high predictive power for patients with AD (Shapiro, Benedict, Schretlen, & Brandt, 1999).

Brief Visuospatial Memory Test – Revised (BVMT-R)

The BVMT-R provides a measure of visual memory (Benedict, 1997). Participants are shown a page with six line figures for ten seconds. The page is removed and the participant is asked to draw as many of the figures as they can remember. This is repeated three times to assess immediate visual recall and learning. A delayed recall trial is conducted 20-25 minutes after the immediate recall portion of the test. In addition, a recognition trial is completed where participants are presented with line figures and asked if each figure was present on the original display. This instrument has strong construct and predictive validity and is highly correlated with other assessments used for measures of learning and memory; a correlation that remains even in older adults outside of the range of the BVMT-R's normative data (Benedict, Schretlen, Groninger, Dobraski, & Shpritz, 1996; Kane & Yochim 2014).

Frequency of Forgetting-10 Scale

This 10-item self-report scale provides a measure of memory self-efficacy. Participants' raw scores are converted into a Rasch score, which is the measurement statistic used for this instrument. This conversion relates the parameters of each item difficulty and self-efficacy level to ensure that participants with low self-efficacy are more likely to report frequent failures, whereas participants with high self-efficacy are more likely to report rare or no failures. This shortened version is derived from a long-version of the Frequency of Forgetting Scale, contained within the Memory Functioning Questionnaire (Gilewski, Zelinski & Schaie, 1990)).

Patient Health Questionnaire-9 (PHQ-9)

The PHQ-9 is a self-report instrument used for assessing the severity and frequency of depressive symptoms. The PHQ-9 has a high internal reliability (Cronbach's alpha=0.89), with a sensitivity of 88% and specificity also of 88% for scores in the moderate depression and above range (Kroenke et al., 2001). It has been validated with older adults (Ell et al., 2005) and for use as a screening tool for older adults with cognitive impairment (Boyle et al., 2011).

Cognitive Training Program

The cognitive training program completed was entitled Lively Mind. The program was developed by the New England Cognitive Center (NECC), a non-profit organization that specializes in developing research-based cognitive fitness programs. These programs are designed to systematically stimulate six major cognitive domains/skills (i.e., processing speed, attention, memory, language, visual spatial skills, and executive functioning/problem solving), instead of focusing on only one or two cognitive skill areas like many other programs. Lively Mind targets individuals who may have been diagnosed with mild or early-stage dementia and consists of 24 one-hour sessions designed to be delivered over 8-12 weeks. The program includes a series of paper and pencil activities that gradually increase in difficulty over time. The content of the activities is designed to be appropriate for adults, challenging, varied, and enjoyable (New England Cognitive Center). Classes are designed to be conducted in groups as opposed to using a computerized administration format. A typical class allocates ten minutes of practice to each of the six cognitive domains. Each activity begins with the trainer providing instruction to the group on how to complete the task, and then participants are able to practice the activities individually.

Procedures

A pre-post quasi-experimental design was used in this study. Participants were evaluated with the battery of neuropsychological assessments prior to and after completing the cognitive training course, which was approximately 12 weeks after pre-treatment testing was completed. Additionally, at the request of participants and activities staff, four individuals completed the class in its entirety a second time through, resulting in a pre-post-secondary-post data set. All assessments were completed by the researchers or graduate students trained in the administration of the tests. These assessments were completed at the facility over two approximately thirty-minute minute sessions in order to minimize fatigue. Testing was complete within one week of starting the classes and within one week of completing the classes.

Cognitive training courses were led by the activities directors at the facility. Prior to beginning the course, the directors were trained by the director of the NECC on how to properly lead the program and utilize the materials included. Participant attendance was tracked throughout the course, and all participants included completed 75% or more of the course for which data was gathered.

Results

Due to the small sample size in this project, inferential statistical analyses would not have sufficient power to detect change. Thus, Cohen's d effect size statistic was used to assess change. Morris and DeShon's (2002) equation 8 was used in the calculation of effect size in order to correct for dependence between means. Classification of effect sizes as set forth by Cohen (1988) were used in the determination of magnitude of effect; specifically, a small effect from 0.2 to 0.49, a medium effect from 0.5 to 0.79, and a large effect of 0.8 and greater. As the program was completed twice, results will be reported for each round of testing. The means, standard deviations, and effect sizes for each round of completion are displayed in Table 1.

Global Cognitive Ability

Participants' 3MS scores prior to and following the cognitive training course were compared. There was a small negative effect (-0.11) on 3MS scores following the first course of training, although it does not reach the cutoff for a small effect size set forth by Cohen. Following the second course of training, a negligible effect of -0.03 was found, demonstrating stability in global cognitive ability for participants who completed the additional course.

Attention

Forward Digit Span

Simple attention, as measured by the ability to listen to and correctly repeat back a list of digits, was compared before and after cognitive training. A large negative effect size (-0.94) was observed in participants' scores following the first course of cognitive training. However, the opposite was observed for those participants completing the second course of cognitive training, with a medium positive effect size of 0.66 being found.

Backward Digit Span

Participants' working memory ability was assessed by listening to a list of digits and repeating it backwards. In both the first and second course of cognitive training, no significant effect size was observed (-0.10 and 0.00, respectively), indicating stability in working memory scores across both courses of training.

Brief Test of Attention

The BTA is a measure of selective attention. First, participants listen to a list of both numbers and letters and are to keep track of only how many numbers were presented. Then, the task is repeated, but keeping track of only how many letters were presented. The results of both these trials are used to calculate the total score. A small positive effect size was seen for participants' scores following the first course of cognitive training (0.21), while a negligible effect size was seen following the second course of training (-0.09).

Language

Language and verbal fluency were measured by the COWAT. This instrument requires participants to list as many words as they can in one minute that begin with a given letter. A small negative effect size (-0.39) was observed following the first course of testing. Conversely, a large positive effect size was observed following the second course of testing (0.86).

Executive Functioning and Perceptual Speed

Trail Making Test Part A

Part A provides a measure of perceptual speed. Participants are required to connect the numbers 1-25 on a page as quickly as they can. Both courses of cognitive training resulted in negligible effect sizes (-0.08 and -0.12, respectively), demonstrating stability in perceptual speed scores across both courses.

Trail Making Test Part B

Part B provides a measure of executive function, requiring participants to connect a series of numbers and letters in alternating order. A medium negative effect size (-0.60) was observed following the first course of cognitive training. However, it should be noted that only two of the six participants completed the task within the parameters of the test in the pre-testing, and none of the participants completed the task in the post-testing. Additionally, in the post-testing following the second course, only one participant completed the task, resulting in a medium positive effect size of 0.50. For these reasons, the effect sizes for executive function should be interpreted with caution.

Visual-Spatial Skills

Visual-spatial skills were measured by the visual puzzles subtest. The first course of cognitive training resulted in a medium negative effect size of -0.68. Conversely, the second course of testing found a large positive effect size of 1.31.

Verbal Memory

Immediate Recall

The Hopkins' Verbal Learning Test measures verbal recall through the presentation of a list of words. Participants are read the list and then asked to repeat back as many of the words as they can remember. This is done three times to provide the total recall score. No effect size (0.00) was observed following the first course of training, indicating stability on recall scores. However, a small negative effect size (-0.48) was observed following the second course of training.

Delayed Recall

The HVLT also provides a measure of delayed recall. After 20-25 minutes following the recall portion, participants are asked to recall as many words as they can remember from the original list. This portion of the test may have been too difficult for the population, as only two participants were able to recall any words in the pre-testing. This pattern was repeated in the post-testing, with one participant of the six recalling any words, and one participant of the four in the second post-testing. Based on this limited data, a small negative effect size was observed in the first cognitive training course (-

0.41), while a medium positive effect size was observed in the second course (0.50). However, this data should be interpreted with caution due to the small amount of participants who were able to complete the task.

Recognition

A recognition index is provided within the HVLT as well. Participants are read a longer list of words and asked to identify if each word was or was not present on the original list. The recognition score is based on the number of hits (words accurately identified as present) minus false alarms (words incorrectly identified as present). A negligible effect size was observed following the first training course (0.08), but a small negative effect was seen following the second (-0.38).

Visual Memory

Immediate Recall

The Brief Visuospatial Memory Test – Revised (BVMT-R) assesses visual memory. The participant is presented with a display containing six line figures for 10 seconds and then asked to draw as many of the figures as they can remember. This is done three times to assess learning. A large negative effect size for recall scores was seen after the first course (-1.08). However, a small positive effect size was seen following the second cognitive training course (0.39).

Delayed Recall

The BVMT-R provides a measure of delayed recall as well. Twenty to twenty-five minutes after the immediate recall trials, the participant is asked to draw as many of the figures as they can remember in their correct place on the page. A small negative effect size of -0.41 was seen after the first course of cognitive training. However, only three of the six participants were able to complete the trial in pre-testing, and two of the six in post-testing. The second course of cognitive training resulted in a negligible effect size (0.12), with only one of the four participants completing the trial in the second post-testing. Thus, the effect sizes presented for delayed visual recall should be interpreted with caution.

Recognition

The BVMT-T contains a recognition trial in which participants are shown several shapes and asked to identify if each shape was present on the original display. The recognition score is calculated by subtracting hits (shapes correctly identifies as present) minus false alarms (shapes incorrectly identified as present). The first trial showed a very small positive effect, although it did not reach the cutoff for a small effect size set forth by Cohen (0.13). However, after the second cognitive training course, a large positive effect of 1.31 was observed.

Memory Self-Efficacy

The Frequency of Forgetting-10 scale assess the participants' perspective of their own memory through the calculation of a Rasch score. Rasch scores provide a measure of memory of self-efficacy ranging from -5.14 to 5.04. Individuals reporting rare or no failures of memory tend to have higher scores in the positive range, whereas those with frequent failures tend to have lower scores in the negative range. A medium negative effect of -0.50 was found on Rasch scores following the first course of cognitive training (indicating a decline in memory self-efficacy), while a negligible effect size was seen following the second course of training (0.03).

Depressive Symptoms

The Patient Health Questionnaire-9 provides a measure of depressive symptoms. Higher scores on the PHQ-9 indicate more frequent and severe depressive symptoms. Following the first course of cognitive training, a small negative effect size was observed, although it did not reach Cohen's cutoff for significance (-0.18). This indicates that depressive symptoms slightly increased following the first course of cognitive training. However, following the second course, a small positive effect size was observed that did reach the standards set forth by Cohen (0.20), indicating that depressive symptoms decreased at a greater magnitude following the second course of training.

Discussion

In summary, following the first course of training, the majority of the cognitive domains assessed showed stability. Only one cognitive domain of the fourteen assessed showed improvement, and five of the fourteen showed declines. Two of the fourteen domains (executive function and delayed verbal recall) proved to be too difficult for the population, with less than half the participants being able to complete the measure at any point during the testing. These results considered alone do not lend much support to the use of cognitive training in order to improve cognitive impairment; only perhaps to stabilize certain domains from further decline.

Stability in itself is an encouraging finding, particularly in a population where decline is expected. Previous studies have also found stability in multiple cognitive domains following completion of a cognitive training course. For instance, Mate-Kole and colleagues (2007) observed stability or improvement in all of the cognitive domains assessed, while Kanaan (2014) found stability in memory, number-letter switching, and motor speed. This is similar to our findings of stability in global cognitive ability, verbal memory, working memory, and perceptual speed. Interestingly, however, declines were seen in the areas of visual memory as well as simple attention, differing slightly from these findings. When discussing these results, it may be worthwhile to return to Bahar-Fuchs and colleagues' review (2013) that found no association between cognitive training and either positive or negative effects in relation to any reported outcomes. One potential interpretation these findings may be that rather than consistent improvement or consistent declines in certain domains, stability may be the more overwhelming effect seen from cognitive training programs.

An additional interpretation may be that the literature is too limited at this point to be able to discern patterns of cognitive domains that consistently respond to training and those that do not. The amount of research done with programs that are operationally defined as cognitive training (according to Clare's earlier cited definition) is minimal, and particularly those that are done using randomized control trials. In fact, in Bahar-Fuchs' review, only 11 instances of cognitive training RCTs were found. Furthermore, the authors point out that the overall quality of the trials examined was low to moderate, as many of the studies had a high risk of bias. Additionally, many of the trials evaluate cognitive change using a wide assortment of instruments. This variability in measurement makes analyzing the overall effects of cognitive training difficult to reliably assess across studies. Going forward, it may be beneficial to reach a general consensus about which measures are best suited for evaluating particular cognitive domains in order to address this measurement complication.

Interestingly, after participants completed the second course of cognitive training, a much different pattern of responding was observed. Although some cognitive domains assessed showed stability once again (4/14), a greater number of cognitive domains showed improvement (5/14) rather than decline (2/14). In this course of testing, three of the fourteen cognitive assessments were unable to be completed by half of the participants at any point during the testing, indicating that the measures may have been too difficult for the population. The additional information gathered following the second course indicates that there may be additional benefits to the use of the cognitive training program aside from what is indicated by considering the first course of training alone. This finding is novel in that existing studies rarely assess the impact of continued training.

This variable responding following each course of training may relate to the discussion regarding what the optimal "dose" of cognitive training is. This pattern perhaps indicates that a longer training intervention may be more effective when compared with a shorter one. Alternatively, it is possible that there were additional variables that differed between the classes that are not well understood. For instance, in the second course of training, all activities had been completed by both participants and instructors previously. This previous experience may have allotted more time to be spent on completing and practicing the tasks, rather than explaining or demonstrating proper completion. Future studies that repeat these courses for research purposes may want to employ measures to track the fidelity between the administration of courses.

Furthermore, it is possible that the observed difference is caused by the dropout of one or both of the participants that did not complete the second course. It is reasonable to consider that perhaps one of the participants found the course too difficult, thus bringing the mean scores down and opting out of the second course of training. To examine this possibility, effect sizes were calculated a second time for the first course of training, but this time exclusively using the four participants who completed both courses of class. The only cognitive task that showed an improved effect size with this manipulation was the measure of executive function, Trails B, with a change from a large negative effect (-1.20) to a medium negative effect (-0.78). However, this is one of the cognitive tasks that proved to be too difficult for the majority of participants to complete. All other cognitive domains either showed no difference in magnitude of effect or showed a small decline in effect size, demonstrating that the dropout of two participants did not have a deleterious effect on the results of the first course of cognitive training.

Moreover, these findings may indicate that participants who completed the second course showed a return to baseline levels of performance at the start of training. However, in looking at comparisons of the effect sizes from pre- to second-post assessments for the four participants who completed both classes, the response is somewhat variable. Three measures showed improvement, three showed stability, five showed decline, and three measures were unable to be completed. These mixed results indicate that a return to baseline may be occurring in certain domains, but other areas are responding more variably.

In further attempting to understand the effects of the second cognitive training course, it may be useful to examine individual participant data: comparing pre-testing scores to those following the second course. In terms of a true return to baseline, few participants displayed this pattern. Participant WJX005 returned to baseline scores in the domains of simple attention and depressive symptoms following a decline after the first cognitive training course. Although, in comparing her pre- and second-post-test scores, improvement was seen in six domains, while decline was seen in eight, indicating that there was not necessarily a pattern of stability. Participant SVX008 also showed a true return to baseline at second-post-testing after a decline in visual recognition following the first course of training. This was the only domain that showed stability, however. The remaining twelve domains were divided equally into improvements and declines, and three measures were unable to be completed across all testing sessions.

Participant RDX007 responded somewhat similarly, showing stability across a total of four domains (simple attention, visual-spatial skills, visual recognition, and depressive symptoms). However, in this case it was not a return to baseline; rather, the scores stayed stable in each domain across all three rounds of testing. This participant further showed improvement in two domains, decline in eight, and the inability to complete two domains when comparing pre- and second-post-test scores. Finally, participant DJX011 showed no true return to baseline or stability in any of the cognitive domains measured. This participant's scores were evenly split between improvement and decline at seven domains each, with two domains that were unable to be completed.

As is apparent, there is considerable variability in responding, both between individuals and within individuals. A select few areas are displaying a return to baseline, but considerably more frequently, performance from the first to the last round of testing is showing either measurable improvements or declines. As there was a relatively equal mix of improvement and decline across individuals, when totaled and examined as group data, this variability in responding across participants is hidden and appears as stability. When this information is considered in tandem with the effect size data from first to last testing, it shows consistency in the lack of a clear pattern, and further reiterates the variability of responding seen across participants and across cognitive domains. Although when examining the group data it is reasonable to conclude that the pattern of decline following the first course of training and subsequent improvement following the second course is simply a rebound to baseline performance, it appears that there may be additional factors causing the overall improvement effect of the second course that remain unclear. Further investigation into the effects of repeated training could be beneficial in beginning to address these questions.

In summary, with the responding currently seen, evidence points to a unique effect of the second round of cognitive training. Furthermore, although there are some areas of decline from pre- to second-post-testing, if we consider that this difference occurred over the period of about six months, seeing improvement and stability in any domains when decline is expected is a favorable outcome of this repeated cognitive training.

Limitations and Future Directions

Despite some encouraging, although highly variable findings, this study is not without limitations. First, the study is limited by its small sample size and the homogeneity of the sample. All participants were white females with an education level greater than high school, and more principally, all of the participants were nuns. This background contains life experience and a degree of spirituality that tends to be unique when compared with the general population, necessitating the replication of these results with individuals from a wider array of backgrounds. Continued research with larger and more diverse samples will help determine the reliability and generalizability of the findings of the current study.

Second, the lack of control group is a significant limitation of this study. A control group would allow researchers to more accurately determine if the cognitive training course had an effect on cognition, and potentially could further demonstrate which domains may be most affected. Furthermore, a control group may be useful in understanding what the areas of decline seen after training truly indicate. As decline is expected with a cognitively impaired population, a control group could distinguish the expected levels of decline in this population from the levels of decline seen in the individuals completing cognitive training. Even though a number of domains did show decline over the course of training in this study, it is possible that the decline seen is less than what would be expected without intervention. Regrettably, we cannot make such conclusions without measures of typical decline for comparison.

Unfortunately, this lack of a control group is a reality of completing this type of evaluative research. Considering that the cognitive training program was being administered at the facility regardless of the researchers' involvement (rather than for the sole purpose of conducting efficacy research), it is worthwhile that as much information was able to be gathered as is reported here. Further studies that include either wait-list control groups or active control groups comprised of individuals that complete physical (e.g., exercise), social (e.g., book clubs), or creative activities (e.g., crafting) could potentially begin to reveal further patterns to either refute or support the use of cognitive training programs.

Additionally, while this study did provide novel information on the effects of repeated training, the extent to which benefits lasted after training ceased were not assessed. Future studies should include follow-up assessments to determine the duration of time that benefits may be maintained. Understanding how benefits of cognitive training persist over time could potentially reveal when or if further intervention is needed. Perhaps it will be unnecessary to repeat a course in its entirety to see these benefits, but some form of "booster" or "refresher" cognitive training could possibly prolong the effects of the course more efficiently. These questions provide an area of further investigation as to the optimal dose or delivery of cognitive training.

As discussed previously, the task of measuring cognitive domains is somewhat ambiguous and largely left up to the researchers. There are several tools available for use for each cognitive domain, so selecting what will be most appropriate for a given population (e.g., those without cognitive impairment vs. those with dementia of mild to moderate severity) can be challenging. This is evident in this study, as several of the instruments proved to be too difficult for the level of impairment within the population. In order to properly measure these cognitive domains, it will be necessary to find different measures of some constructs for more impaired individuals. Furthermore, an additional difficulty in using such psychometric instruments to measure cognition is that it is unclear how well the information translates to changes in daily life. Ideally, the use of cognitive training programs such as this would be beneficial for individuals outside of just cognitive performance (in social interactions, general mood, or perhaps in being able to remain at home longer). Future research will need to implement methods to measure the effects of cognitive training on these other, non-cognitive outcomes as well.

Conclusions

Overall, these findings provide mixed support for the use of cognitive training programs for individuals with mild to moderate cognitive impairment. These results indicate that cognitive training may provide some degree of cognitive stability, but further or repeated training may lead to stability as well as improvements in some cognitive abilities. Further replication with larger, more heterogeneous participants may be beneficial in discerning patterns of improvement or decline due to cognitive training interventions.

Table 1.

Pre- and post-assessment means and standard deviations for cognitive training courses

	First Course				Second Course			
	Pre	Post			Pre	Post		
Assessment	Mean (SD)	Mean (SD)	Cohen's *d*	Effect size & direction	Mean (SD)	Mean (SD)	Cohen's *d*	Effect size & direction
3MS	73.17 (4.31)	72.17 (7.60)	-0.11	NS	72.72 (9.71)	72.50 (11.82)	-0.03	NS
Forward digit span correct	8.67 (2.25)	6.83 (0.98)	-1.13	Large -	6.75 (0.96)	8.00 (1.41)	0.66	Medium +
Backward digit span correct	7.00 (1.55)	6.83 (1.72)	-0.1	NS	7.00 (1.83)	7.00 (1.63)	0	NS
BTA total	7.67 (4.63)	9.17 (4.31)	0.21	Small +	8.25 (4.99)	7.75 (0.96)	-0.09	NS
Letter Fluency Total	21.17 (12.72)	20.33 (12.19)	-0.39	Small -	18.25 (6.99)	21.50 (6.14)	0.86	Large +
Trail making test A	56.17 (20.61)	58.00 (22.78)	-0.12	NS	62.00 (27.87)	63.00 (39.20)	0.06	NS
Trail making test B	40.00 (66.93)	0.00 (0.00)	-1.2	Large -	0.00 (0.00)	26.50 (53.00)	0.5	Medium +
Visual Puzzles	9.00 (2.37)	7.83 (.98)	-0.68	Medium -	8.00 (1.15)	9.25 (1.71)	1.31	Large +
HVLT total recall	12.17 (3.43)	12.17 (3.49)	0	NS	12.50 (3.42)	11.25 (2.87)	-0.48	Small -
HVLT delayed recall	1.17 (1.83)	0.67 (1.63)	-0.41	Small -	0.00 (0.00)	0.25 (0.50)	0.5	Medium +
HVLT recognition	3.67 (4.97)	4.00 (2.37)	0.08	NS	4.50 (2.89)	2.75 (2.75)	-0.38	Small -
BMVT total recall	5.50 (3.39)	2.33 (2.16)	-1.08	Large -	3.25 (2.06)	4.50 (2.89)	0.39	Small +
BMVT delayed	0.83 (0.98)	0.50 (0.84)	-0.41	Small -	0.50 (1.00)	0.75 (1.50)	0.12	NS
BMVT recognition	2.67 (0.82)	2.83 (1.60)	0.13	NS	2.25 (1.71)	3.50 (1.73)	1.31	Large +
Frequency of Forgetting Rasch score	0.57 (0.55)	0.41 (0.41)	-0.5	Medium –	0.50 (0.41)	0.52 (0.89)	0.03	NS
PHQ-9 score	4.33 (4.72)	4.00 (5.62)	-0.18	NS	1.25 (1.50)	1.50 (1.29)	0.2	Small +

Appendix

Table 2.

Pre- and post-training data for participant BME001

	Pre Mean	Post Mean	Change
3MS	68.00	72.00	+4.00
Forward digit span correct	5.00	6.00	+1.00
Backward digit span correct	5.00	5.00	0.00
BTA total	8.00	9.00	+1.00
Letter Fluency Total	12.00	8.00	-4.00
Trail making test A	40.00	44.00	-4.00*
Trail making test B	0.00	0.00	N/A*
Visual Puzzles	8.00	8.00	0.00
HVLT total recall	13.00	15.00	+2.00
HVLT delayed recall	4.00	4.00	0.00
HVLT recognition	1.00	3.00	+2.00
BMVT total recall	6.00	0.00	-6.00
BMVT delayed	1.00	1.00	0.00
BMVT recognition	2.00	4.00	+2.00
PHQ-9	13.00	15.00	+2.00*
Frequency of Forgetting Rasch score	0.57	0.57	0.00

Note: Participant BME001 showed improvement on seven measures, stability on five measures, decline on three measures, and the inability to complete one measure.
* = A decrease in score indicates improvement.

Table 3.

Pre- and post-training data for participant CMB010

	Pre Mean	Post Mean	Change
3MS	73.00	70.00	-3.00
Forward digit span correct	10.00	8.00	-2.00

Backward digit span correct	8.00	8.00	0.00
BTA total	8.00	9.00	+1.00
Letter Fluency Total	43.00	41.00	-2.00
Trail making test A	44.00	56.00	+12.00*
Trail making test B	0.00	0.00	N/A *
Visual Puzzles	9.00	7.00	-2.00
HVLT total recall	11.00	8.00	-3.00
HVLT delayed recall	0.00	0.00	N/A
HVLT recognition	-2.00	3.00	+5.00
BMVT total recall	3.00	1.00	-2.00
BMVT delayed	0.00	0.00	N/A
BMVT recognition	4.00	4.00	0.00
PHQ-9	6.00	4.00	-2.00*
Frequency of Forgetting Rasch score	0.30	-0.10	-0.40

Note: Participant CMB010 showed improvement on three measures, stability on two measures, decline on eight measures, and the inability to complete three measures.
* = A decrease in score indicates improvement.

Table 4.

Pre-, post-, and second-post-training data for participant RDX007

	Pre Mean	Post Mean	Change	Second Post Mean	Change
3MS	79.00	66.00	-13.00	77.00	+11.00
Forward digit span correct	7.00	7.00	0.00	7.00	0.00
Backward digit span correct	9.00	6.00	-3.00	7.00	+1.00
BTA total	13.00	9.00	-4.00	10.00	+1.00
Letter Fluency Total	20.00	19.00	-1.00	27.00	+8.00
Trail making test A	57.00	51.00	-6.00*	51.00	0.00*
Trail making test B	160.00	0.00	-160.00*	0.00	N/A*
Visual Puzzles	9.00	9.00	0.00	9.00	0.00
HVLT total recall	13.00	12.00	-1.00	9.00	-3.00
HVLT delayed recall	0.00	0.00	N/A	0.00	N/A
HVLT recognition	6.00	7.00	+1.00	0.00	-7.00
BMVT total recall	8.00	5.00	-3.00	4.00	-1.00

BMVT delayed	0.00	0.00	N/A	0.00	N/A
BMVT recognition	2.00	2.00	0.00	2.00	0.00
PHQ-9	3.00	3.00	0.00*	3.00	0.00*
Frequency of Forgetting Rasch score	-0.17	-0.10	+0.07	-0.59	-0.49

Note: Participant RDX007 showed improvement on three measures, stability on four measures, decline on seven measures, and the inability to complete two measures after the first course of cognitive training. Following the second, there was improvement on four measures, stability on five measures, decline on four measures, and the inability to complete three measures.
* = A decrease in score indicates improvement.
** = In this case, the participant completed the first assessment, but the score of 0 indicates inability to complete the assessment again. The change column does not accurately reflect the improvement according to the above note; rather the inability to complete the task is considered a decline.

Table 5.

Pre-, post-, and second-post-training data for participant SVX008

	Pre Mean	Post Mean	Change	Second Post Mean	Change
3MS	73.00	64.00	-9.00	57.00	-7.00
Forward digit span correct	11.00	8.00	-3.00	8.00	0.00
Backward digit span correct	6.00	8.00	+2.00	7.00	-1.00
BTA total	5.00	11.00	+6.00	7.00	-4.00
Letter Fluency Total	16.00	17.00	+1.00	19.00	+2.00
Trail making test A	55.00	80.00	+25.00*	67.00	-13.00*
Trail making test B	0.00	0.00	N/A*	0.00	N/A*
Visual Puzzles	6.00	7.00	+1.00	7.00	0.00
HVLT total recall	13.00	12.00	-1.00	9.00	-3.00
HVLT delayed recall	0.00	0.00	N/A	0.00	N/A
HVLT recognition	6.00	7.00	+1.00	0.00	-7.00
BMVT total recall	0.00	1.00	+1.00	1.00	0.00
BMVT delayed	0.00	0.00	N/A	0.00	N/A
BMVT recognition	2.00	0.00	-2.00	2.00	+2.00
PHQ-9	0.00	0.00	0.00*	2.00	+2.00*
Frequency of Forgetting Rasch score	1.16	0.77	-0.39	1.43	+0.66

Note: Participant SVX008 showed improvement on six measures, stability on one measure, decline on six measures, and the inability to complete three measures after the first course of cognitive training. Following the second, there was improvement on four measures, stability on three measures, decline on six measures, and the inability to complete three measures.
* = A decrease in score indicates improvement.

Table 6.

Pre-, post-, and second-post-training data for participant DJX011

	Pre Mean	Post Mean	Change	Second Post Mean	Change
3MS	69.00	76.00	+7.00	71.00	-5.00
Forward digit span correct	9.00	6.00	-3.00	7.00	+1.00
Backward digit span correct	6.00	5.00	-1.00	5.00	0.00
BTA total	0.00	12.00	+12.00	7.00	-5.00
Letter Fluency Total	8.00	10.00	+2.00	14.00	+4.00
Trail making test A	96.00	89.00	-7.00*	114.00	+25.00*
Trail making test B	0.00	0.00	N/A*	0.00	N/A*
Visual Puzzles	8.00	7.00	-1.00	9.00	+2.00
HVLT total recall	8.00	8.00	0.00	9.00	+1.00
HVLT delayed recall	0.00	0.00	N/A	0.00	N/A
HVLT recognition	9.00	7.00	-2.00	4.00	-3.00
BMVT total recall	7.00	5.00	-2.00	5.00	0.00
BMVT delayed	2.00	0.00	-2.00	3.00	+3.00
BMVT recognition	3.00	3.00	0.00	5.00	+2.00
PHQ-9	3.00	0.00	-3.00*	0.00	0.00*
Frequency of Forgetting Rasch score	1.24	0.77	-0.47	1.00	+0.23

Note: Participant DJX011 showed improvement on five measures, stability on two measures, decline on seven measures, and the inability to complete two measures after the first course of cognitive training. Following the second, there was improvement on seven measures, stability on three measures, decline on four measures, and the inability to complete two measures.
* = A decrease in score indicates improvement.

Table 7.

Pre-, post-, and second-post-training data for participant WJX005

	Pre	Post		Second Post	
	Mean	Mean	Change	Mean	Change
3MS	77.00	85.00	+8.00	85.00	0.00
Forward digit span correct	10.00	6.00	-4.00	10.00	+4.00
Backward digit span correct	8.00	9.00	+1.00	9.00	0.00
BTA total	11.00	1.00	-10.00	8.00	+7.00
Letter Fluency Total	28.00	27.00	-1.00	26.00	-1.00
Trail making test A	45.00	28.00	-17.00*	20.00	-8.00*
Trail making test B	80.00	0.00	-80.00**	106.00	+106.00**
Visual Puzzles	10.00	9.00	-1.00	11.00	+2.00
HVLT total recall	18.00	14.00	-4.00	15.00	+1.00
HVLT delayed recall	3.00	0.00	-3.00	1.00	+1.00
HVLT recognition	9.00	2.00	-7.00	6.00	+4.00
BMVT total recall	9.00	2.00	-7.00	8.00	+6.00
BMVT delayed	2.00	2.00	0.00	0.00	-2.00
BMVT recognition	3.00	4.00	+1.00	5.00	+1.00
PHQ-9	1.00	2.00	+1.00*	1.00	-1.00*
Frequency of Forgetting Rasch score	0.30	0.57	+0.27	0.23	-0.34

Note: Participant WJX005 showed improvement on five measures, stability on one measure, and decline on ten measures after the first course of cognitive training. Following the second, there was improvement on eleven measures, stability on two measures, and decline on three measures.
* = A decrease in score indicates improvement.
** = In this case, the participant completed two of the three measures, but the score of 0 indicates inability to complete the assessment. The change column does not accurately reflect the improvement and decline according to the above note; rather the inability to complete the task after the first course is considered a decline, while completing it again after the second course is considered an improvement.

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