THE EFFECTS OF AN ONLINE MOVEMENT AND COGNITIVE DUAL TASK TRAINING PROGRAM FOR COMMUNITY-BASED ADULTS AND OLDER ADULTS ON EXECUTIVE FUNCTION: A PILOT STUDY

A Dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at George Mason University

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DEDICATION

This is dedicated to my parents, who have given me unconditional love and support my whole life.

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I would like to thank my advisor and mentor, Dr. Andrew Guccione for the unwavering support and guidance throughout the duration of my doctoral education. Without his dedication and leadership every step of the way, this would not have been possible. Thank you to my committee members, Dr. Higgins, Dr. Adams, Dr. Min and Dr. Reis for their support and feedback, each played an essential part in the completion of this degree. Thank you to our wonderful participants for their interest in our study and who volunteered their time to further science. Thank you to my colleague and friend Marti Carroll, who encouraged me to dream big and supported my ambitions from the very beginning of my career. Finally, thank you to my brother who through his own educational perseverance, helped give me the courage to pursue my own.

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LIST OF ABBREVIATIONS

Brain and Balance	BAB
Reaction Time Simple	RTS
Reaction Time Choice	RTC
Digit Span Forward	DS-f
Digit Span Backwards	DF-bk
Letter Number Sequencing	LNS
Spatial Addition	SA
Visual Spatial Working Memory	VSWM

ABSTRACT

THE EFFECTS OF AN ONLINE MOVEMENT AND COGNITIVE DUAL TASK TRAINING PROGRAM FOR COMMUNITY-BASED ADULTS AND OLDER ADULTS ON EXECUTIVE FUNCTION: A PILOT STUDY

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George Mason University, 2022

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Objective: To examine the effects of a 30-minute, 3x/week, 24-session at home online movement and cognitive exercise program on executive function in community-based adults and older adults. *Background*: Cognitive performance is known to decline over time. Essential for functional independence through the aging process, cognitive performance can determine whether an individual has the ability to live independently, drive safely, and manage medications and finances. There is a growing body of evidence supporting the use of dual movement and cognitive interventions to improve executive function in the aging population. No known studies have examined the impact of an online dual movement and cognitive training program on attention, visual and auditory spatial working memory and processing speed; three essential contributors to executive function. *Methods*: This was a prospective pre-experimental pilot study. Participants were recruited from the greater Washington, D.C area, including those who reside in

independent living facilities. Twenty-two individuals consented (age: 75.95±3.55; gender: 17F/5M) and completed the Brain and Balance (BAB) program which consisted of 24-online training sessions, spanning approximates 30 minutes each, 2-3 times per week. *Outcome Measures:* Administered via videoconference, baseline and post intervention measures of cognitive performance included the Deary-Liewald simple (RTS) and choice (RTC) reaction time task, the forward (DS-f) and backwards Digit Span (DS-bk), Letter Number Sequencing (LNS) and the spatial addition (SA) subset of the Wechsler Memory Scale-IV. *Data Analysis:* Statistical analysis was completed using STATA IC version 16 and Microsoft Excel. Normality was visually confirmed with histogram graphs. A comparison of means pre and post training was completed using a paired t-test with a significance set at level of $p \leq 0.05$. Scatter plots were used to depict individual baseline and post treatment scores for each outcome measure, the difference in scores and mean difference ($mean_{diff}$). Cohen's $d_{unbiased}$ was used to calculate effect size. *Results*: Following BAB, improvements in RTS ($mean_{diff}$ = -10.95ms), RTC ($mean_{diff}$= -37.50ms), DS-f ($mean_{diff}$ = 0.54), DS-bk ($mean_{diff}$ = 0.57), LNS ($mean_{diff}$ = 0.62) were observed. Small effects were observed for DS-f (Cohen's $d_{(unbiased)}$ = 0.201), DS-bk (Cohen's $d_{(unbiased)}$= 0.236), LNS (Cohen's $d_{(unbiased)}$= 0.206). RTS and RTC were treated as non-parametric data, there was a small effect for RTC with r=0.210, however RTS effect was unremarkable at r= 0.053. SA data were grouped by baseline performance (low performers ≤ 10, high performers >10). Following BAB, improvements in low performers ($mean_{diff}$ = 0.60) and small effect (Cohen's $d_{(unbiased)}$ = 0.27) were observed. However, baseline high performers in SA task showed a moderate decline post treatment,

likely attributed to a possible regression towards the mean. *Conclusion*: Participants trended towards improvement in cognitive performance following an online simultaneous movement and cognitive training program. Further research is necessary to determine magnitude of change and functional implications associated with dual movement and cognitive training in this population.

SPECIFIC AIMS

Resilient executive functioning skills, such as processing speed, attention and working memory are critical for maintaining functional independence in aging. These skills are a primary component of cognitive performance. Regrettably, cognitive performance, also, often declines with age. As the population of adults and older adults increases globally, [1,2] so does the prevalence of age-related cognitive decline. Physical training [3–5] and cognitive training[6,7] are accepted methods known to improve cognitive performance in healthy older adults. Furthermore, generally healthy, community dwelling adults and older adults may demonstrate significant improvements in executive function when engaged in in-person simultaneous physical and cognitive training programs.[8–10] However, very little is known about the impact of such programs delivered online, a critical question in a post-pandemic world.

The overarching research question of this study was: What is the impact of an online combined dual movement and cognitive training program on executive function in healthy older adults as evidenced by changes in memory, attention and processing speed? To this end, we proposed the following specific aim and subsequent hypotheses:

Specific Aim: Describe the effects of a twenty-four session, 30-minute per session online exercise program, BAB, on cognitive performance in community dwelling adults and older adults.

H1: BAB will improve attention, as measured by the Forward Digit Span subset of the Wechsler Adult Intelligence Scale version IV[11].

H2: BAB will improve auditory working memory, as measured by the Backward Digit Span subset of the Wechsler Adult Intelligence Scale version IV[11] and Letter Number Sequencing. [12]

H3: BAB will improve visual spatial working memory, as measured by the Spatial Addition subset of the Wechsler Memory Scale version IV.[13]

H4: BAB will improve processing speed, as measured by the Deary-Liewald[14] simple and four-choice reaction time tasks.

Our intent at the conclusion of this prospective pre-experimental pilot study, was to identify the effect of the BAB online virtual program on the cognitive performance domains of attention, auditory and visual spatial working memory (VSWM) and processing speed in community dwelling adult and older adults. These results may support a realignment of treatment priorities towards an emphasis on using multifaceted, task specific and progressively challenging dual movement and cognitive intervention as potential means to target cognition.

INTRODUCTION

Preservation of executive functioning skills such as processing speed, attention and working memory is a key component to maintaining strong cognitive performance with aging. This is unequivocally critical for maintaining functional independence, retaining the ability to live independently and effectively manage finances and medication.[15] Regrettably, cognitive performance often declines with age. In the United States there has been a 33% increase in adults over the age of 65 years old since 2006. At 49.2 million in 2016, this age cohort represents 15.2% of the United States population and by 2050, this demographic is estimated to reach 88.6 million.[1,2] Accompanying this population growth is the risk of increased prevalence of individuals with cognitive impairments. Although variable, age-related cognitive decline is estimated to be 60% attributed to genetics.[15] Therefore the question arises, Is it possible that certain environmental factors can prevent, delay or attenuate cognitive decline?[15]

Generally healthy, community dwelling adults and older adults may demonstrate significant improvements in executive function when engaged in simultaneous physical and cognitive training program.[8–10] The cognitive domains commonly impacted with advanced age are memory, attention and processing speed.[15–17] As the aging population rises over the next several decades it will become critical to identify interventions that work to delay, attenuate, or prevent cognitive decline.

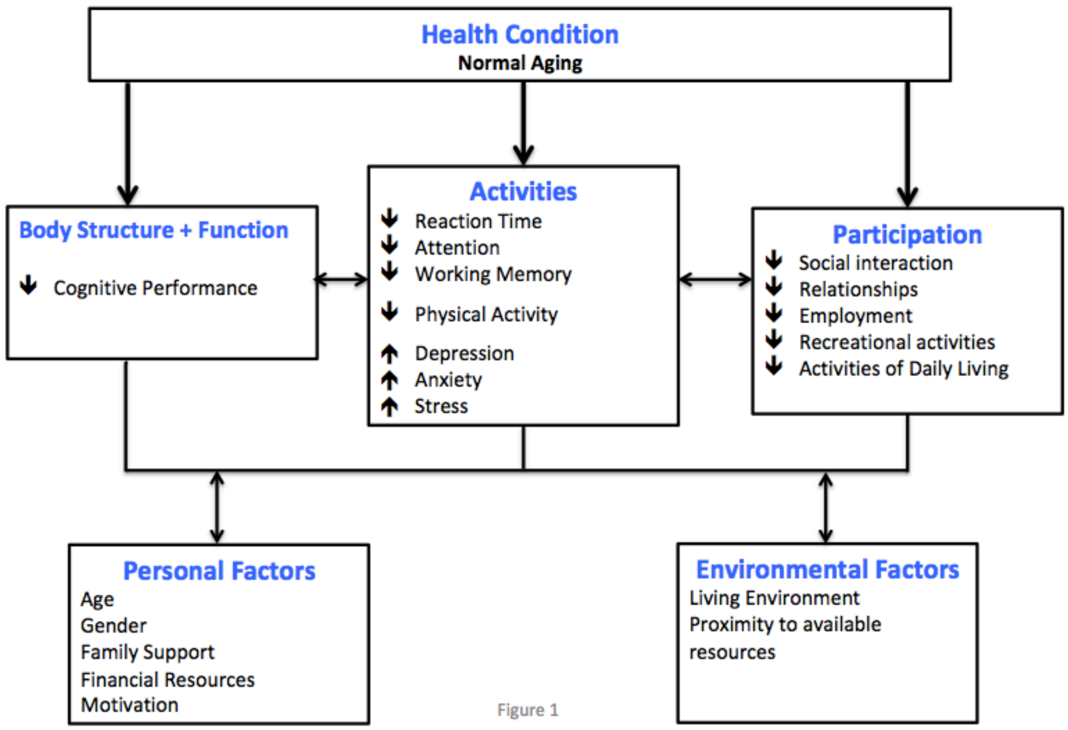


Figure 1 Theoretical Framework

Figure 1 illustrates the theoretical framework of which this study was based using the International Classification of Functioning model.[18] The significance of the relationship between cognition and aging is shown by depicting how a deterioration may affect various aspects of an individual's participation.[19] Furthermore, independence, functional abilities and quality of life are shown to decrease in response to a decline cognitive performance.[20] This decline can be observed when an individual withdraws from social interaction, relationships, employment and recreation activities. In a recent study, Stites reported lower quality of life and worse psychological outcomes such as depression, anxiety, stress, and mental wellbeing in individuals who reported cognitive decline across varying degrees of cognition.[21]

The literature suggests that cognitive deterioration is restorable and potentially preventable since the brain retains plasticity, even in older age.[22–25] Bavelier and Neville operationally define *neuroplasticity* as the capacity of the nervous system to adapt based on present stressors and environmental input.[26] This is seen in both animal[27–30] and human studies. [8,31–33] Exercise-induced changes in brain structure,[34,35] neurophysiology[36,37] and function[3,38] are well documented. Studies show that aerobic exercise may lead to increased cell production in the hippocampus[35], angiogenesis in the form of new capillaries in the brain and increased length and quantity of the dendritic interconnections between neurons.[30,39] These effects are likely due to increases in growth factors such as brain-derived neurotropic factor.[25,35] These structural changes enhance the brain's interconnectivity and create an environment in the central nervous system that is more plastic and adaptive to change.

Literature supports that simultaneous movement and cognitive training is preferable than physical or cognitive training alone in provoking positive changes in cognitive performance in healthy older individuals.[8–10,40] This performance is subject to advanced age, attention, memory and processing speed. Broadly, attention is the ability to selectively focus on a task. It is thought of as the foundation of multiple cognitive functions, including memory and processing speed.[41] Generally speaking, memory is the retention of information however, the type of information and what one does with that information, divides this cognitive domain into a more complex system. Therefore, for the sake of this study we look to exam two specific aspects, passive and active memory. Passive memory is the storage of material in exactly the same format as it was presented; this is reliant on recall rather than information processing.[42] In contrast, active, or working memory requires the storage, integration or manipulation of information; this is reliant on both recall and processing.[42] Finally, processing speed is the speed in which information is sensed, perceived, understood and responded to after specific stimuli.[43]

Cognitive performance deficits contribute to lowered abilities to respond appropriately and adjust proportionally to circumstantial changes that evoke high levels of distraction. Simultaneous training elicits a dual-task challenge, thought to produce a synergistic effect that is advantageous in improving cognitive performance.[40] Figure 2 illustrates how impairment in cognitive performance in the normal aging process may lead to a decline in various aspects of an individuals' life. Cognitive performance influences many cognitive domains; however, the focus of this study was on attention, working memory and processing time, all of which contribute to executive functioning. We believe this relationship to be bidirectional, that independently these executive domains also have an impact on cognitive performance.

Furthermore, impaired cognitive performance may lead to a decline in quality of life, employment, safety, independence, and activities of daily living (ADL), life satisfaction and physical activity. In turn, physical activity, environmental factors influencing safety and ADLs, employment, QOL and life satisfaction can also influence performance in cognitive tasks. Our proposed intervention of simultaneous movement and cognitive training aimed to disrupt this process of decline in cognitive performance by directly impacting several components of executive function.

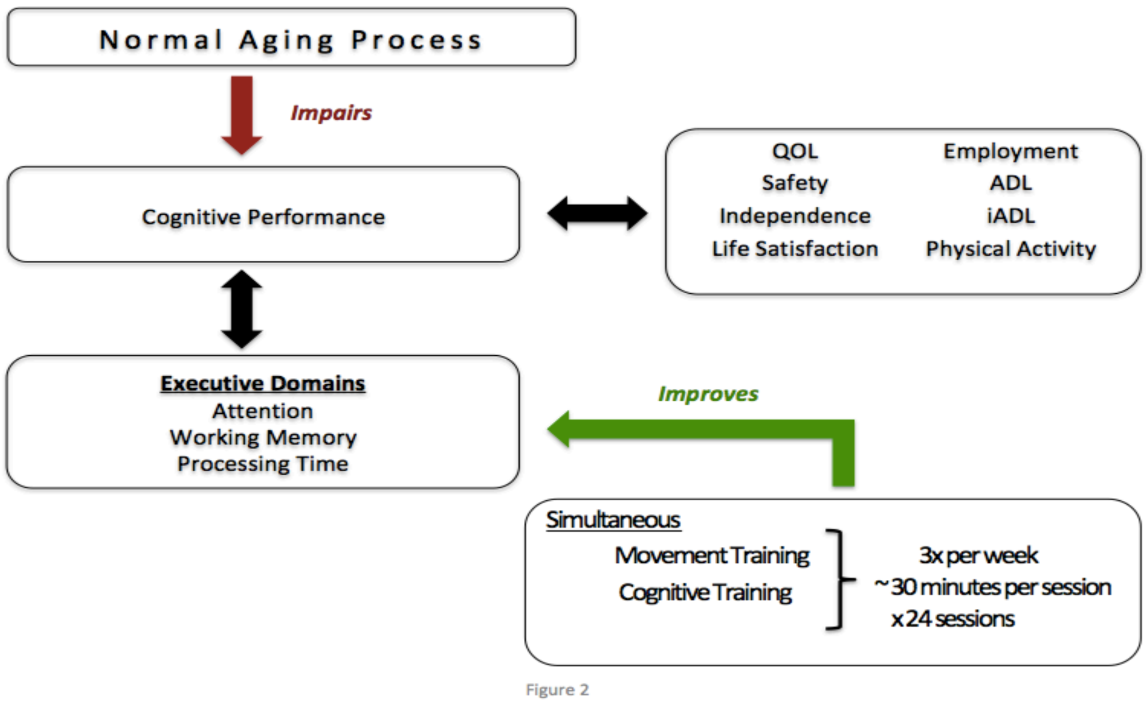


Figure 2 Normal Aging Process

METHODS

Study Design

Figure 3 demonstrates a one-arm 8-week prospective pre-experimental clinical trial. We proposed to test the hypothesis that *Brain and Balance*, a proprietary online program marketed under POWER BRAINing™ (The Braining Center, 2020), would improve executive function in community dwelling adults and older adults. Subjects could not be blinded to the intervention because an exercise program requires active participation. Subsequently, the assessors could not be blinded either due to resource constraints.

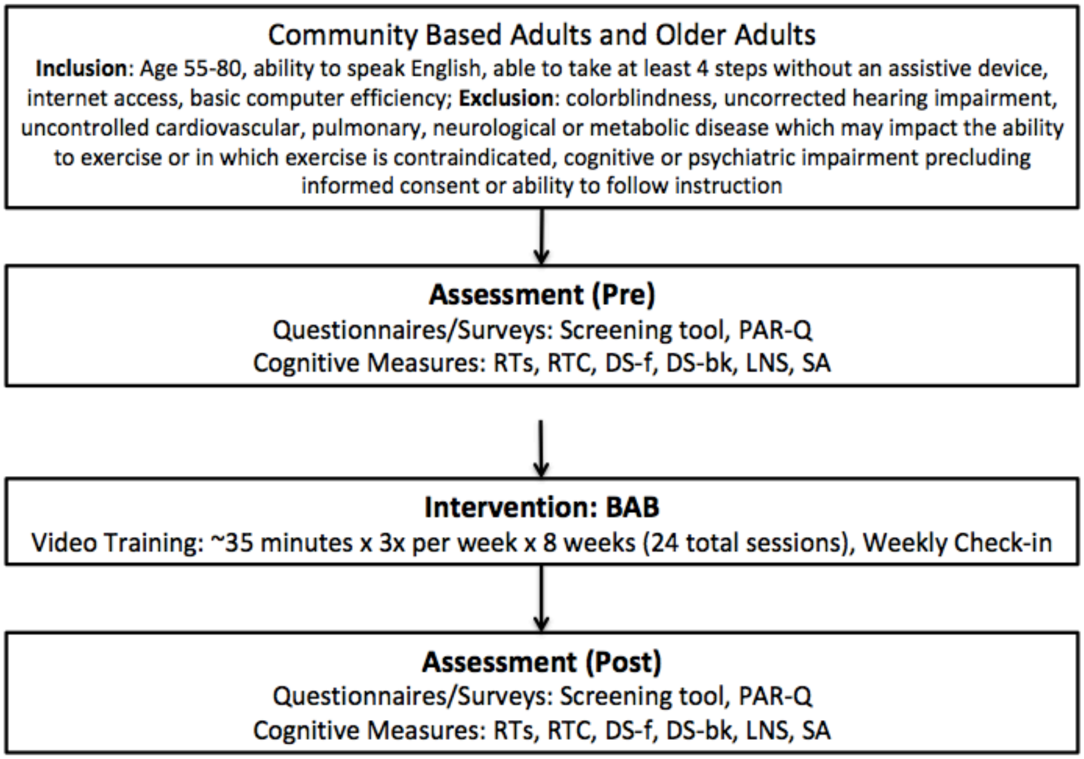


Figure 3

Figure 3 Pre-Experimental Design

Subjects

Participants were recruited from the local community and from local independent senior living facilities in the greater Washington D.C metropolitan area through The Braining Center™. Recruitment was done via email, flyers, word of mouth, and social media. All flyers and marketing were approved by the senior independent living facilities prior to recruitment.

Inclusion criteria for this study included adults between 55 to 80 years of age at the start of the study and those who were able to take at least four steps without an assistive device. Additionally, participants were required to have access to the Internet, display basic computer proficiency, and be proficient in reading and understanding English. Participants were excluded if they presented with one or more of the following: colorblindness, uncorrected hearing impairment, presence of uncontrolled cardiovascular, pulmonary, neurological, or metabolic disease (excluding obesity) which may impact their ability to exercise or in which exercise is contraindicated. Furthermore, participants were excluded if there were present cognitive or psychiatric impairments precluding informed consent or the ability to follow instruction.

Enrollment Procedure

To assess study eligibility and enrollment, individuals were enrolled through the following steps. Those who expressed interest contacted study investigators via the study designated email address. Investigators set up a videoconference to discuss the purpose, qualifications, requirements and procedures of the study. The study specific screening tool questionnaire[44], created via REDcap® was verbally administered. An additional REDcap® link to the Physical Activity Readiness questionnaire[45] was completed to further assess eligibility. If thus far eligible, a link to the informed consent document was sent via REDcap®, reviewed in detail prior to participant signature and voluntarily signed. The form was stored in the secure REDcap® database and was only accessible to the study investigators. Finally, the enrolled subject was scheduled for their baseline assessment. All outcome measurements were completed via videoconference within two weeks of enrollment. Copies of the screening tools and outcome measure are all included in the appendix.

Reaction Time Procedure

Reaction time was assessed using an online visual stimulus test, the Deary-Liewald Task Simple and Four-Choice. [14] The participant was sent a link to the testing website and was asked to follow the directions on the screen. Prior to beginning the assessment the investigator confirmed task comprehension. The test began with RTS. Displayed on the screen was one empty white square and participants were instructed to "Wait until you see a black 'X' in the white square. When that happens, press the spacebar. The goal is to respond as quickly as possible". In the RTC, the screen displayed four equally spaced and sized empty white boxes. There were four possible stimuli and four possible stimulus-response associations. Directions were "Wait until you see a black 'X' in one of the four white squares. When that happens, press the corresponding key (z, x, <or >). You can use both hands and may keep your fingers on the keys throughout the test. The goal is to respond as quickly as possible". The RTS and RTC both allotted eight practice trials, the RTS consisted of twenty test trials and the RTC consisted of forty test trials. The inter-stimulus interval, the time interval between each response and when the next stimulus appeared, ranged between 1 and 3 seconds and was randomized within these boundaries. Results were recorded in milliseconds, a decrease in response time was indicative of a positive change.

Digit Span Procedure

This test is a subset of Wechsler Adult Intelligence Scale- 4th Edition (WAIS-IV).[11] Prior to beginning this assessment each participant completed a simple auditory assessment to ensure auditory comprehension and hearing. The participant was asked to repeat “World, Tree, Pear” out loud. The forward digit span was completed first. Participants were instructed to repeat the numbers in the same order they were read aloud by the examiner. The script was as follows “I am going to read you a sequence of digits, and I want you to try and repeat the digits in the same order they were read out loud. For example, if I say ‘4, 7, 1’, then you would repeat those same digits in that same order”. A short break was given between the DS-f and DS-bk. For the DS-bk, participants were instructed repeat the numbers in the reverse order that was presented aloud by the examiner. The script was as follows “I am going to read you a sequence of digits, and I want you to try and repeat the digits in the reverse order they were read out loud, for example if I say ‘4, 7, 1’, then you would repeat those same digits backwards”. The digits were read in an even tone, at approximately the rate of one digit per second. There were a total of 14 items in both the forward and backwards digit span. Each item was scored as 0 or 1, where 0 represented an incorrect response and 1 represented a correct response. The number reported is the sum of the correct answers. Discontinuation criterion was failure to correctly reproduce two sequences of equal length.

Letter-Number Sequencing Procedure

Participants were instructed to listen to a series of numbers and letters and then repeat the sequence starting first with the numbers in ascending order, followed by the letters in alphabetical order. The script was as follows "I am going to say a set of numbers and letters. Your task is report them by first saying the numbers in ascending order and then the letters in alphabetical order. For example, if I say '9, T, 3, A', your response would be '3, 9, A, T'." The numbers and letters were read in an even tone, at approximately the rate of one digit/number per second. The first sequence began at two and increased in length as the participant progressed. There were a total of 21 items; each item was scored as 0 or 1, where 0 represented an incorrect response and 1 represented a correct response. The number reported is the sum of the correct answers. Discontinuation criterion was failure to correctly reproduce three sequences of equal length.

Spatial Addition Procedure

This is a subset of Wechsler Memory Scale- 4th Edition (WMS-IV).[13] To ensure that the participant did not exhibit colorblindness, participants received a link to the response sheet, which included a black and white grid and red, blue and white dots. They were asked to verbally identify the contents of the page. The investigator guided the participant to organize their computer desktop screen to see both the stimulus book and the answer sheet simultaneously (see appendix). During the assessment each participant was shown two successive 4x4 grids for five seconds each. Both stimuli grids contained (a) blue dots (b) red dots (c) both red and blue dots (d) no dots. The participant was asked to memorize the color and location of the dots to create a final grid. The instructions were as follows "In this next task, you will be shown two grids for 5 seconds each. Each grid will contain red or blue dots. Your task is to create a final grid using the answer sheet with the following guidelines: using both stimulus grids, place one blue dot in each location they appeared. However, if a blue dot appeared in the same location on both grids, indicate this by placing a white dot in that location. Ignore any red dots". The investigator completed one practice trial and the participant completed two sample trials. An example of this assessment is located in the appendix.

INTERVENTION

Content

All video sessions were previously uploaded to a secure website. Exercise-specific instructions were given through verbal explanation and visual demonstration via an on screen avatar. Avatars demonstrated both the cognitive and movement tasks and completed the exercise alongside the participant. Figure 4 illustrates a sample of the types of exercises participants were instructed to complete.

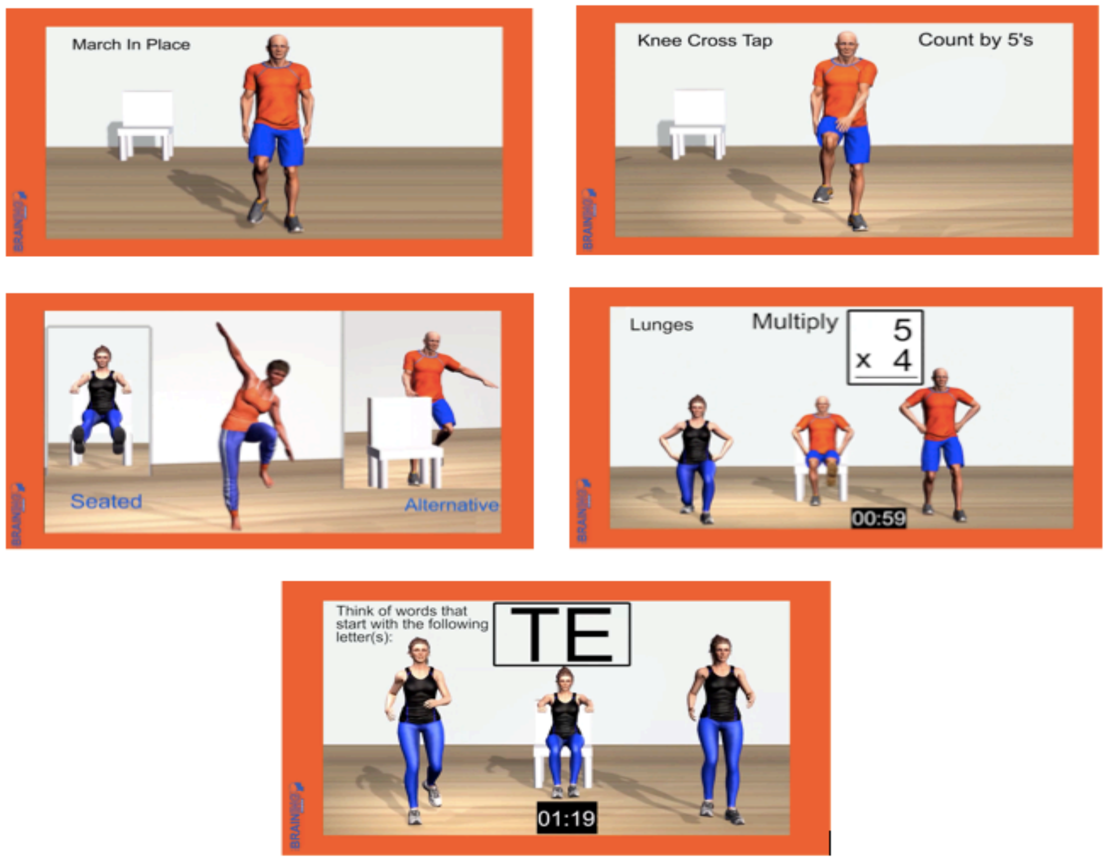


Figure 4

Figure 4 BAB Sample Exercises

The content in the videos were designed to directly facilitate an improvement in both movement and cognitive performance. To promote movement training exercises were structured to keep the participant in motion while maintaining an elevated heart rate using techniques such as squats, marching and upper extremity movements. To increase or decrease the challenge level based on subject ability, each video provided movement adaptation, such as holding onto a chair, completing the exercise seated or changing one's base of support. To promote cognitive performance, participants were instructed to complete simple and complex cognitive tasks, such as mental arithmetic, spatial memory recall and attention all while completing the movement exercises. Videos were presented in a progressively challenging manner for all domains. The progression of movement tasks included integrating narrower base of support exercises such as single leg stance or multi-planar movements versus single plane exercises. Cognitive progression was achieved through altering skill complexity, such as increasing the length of numbers in a sequence during short-term memory tasks. Moreover, cognitive complexity increased by incorporating multistep instructions such as contralateral upper extremity and lower extremity asymmetrical movements or actions. Rest breaks and breathing exercises were built-in within each video to allot for recovery after the more challenging tasks.

Administration

Video access was available online in the participant's home. Video completion was suggested for 2-3 times per week, with at least one rest day in between sessions. Each video ranged from 27-37 minutes in length (average 32 minutes) and could be completed any time of day. Each participant received a weekly call or email to check-in on progress and answer questions.

DATA COLLECTION PROCEDURES

Cultural Competence

This study was open to all who met the inclusion and exclusion criteria regardless of sex, gender identity, ethnicity, religious affiliations, education or sexual orientation. Due to the nature of the training program and heavy reliance on verbal instruction, conversational understanding of English was a requirement.

Treatment Fidelity

Assessors completed extensive rehearsal of all elements of the data collection procedures including use of REDcap® platform for data storage and questionnaire/survey administration, outcome measure administration and videoconferencing. All participants were given access to the same intervention videos via online website with their own unique login information. Weekly check-ins via email or phone call provided opportunity to address participant concerns or questions. Researchers had access to the Power Braining™ platform to collect independent data, including videos subjects viewed, date and time the video was viewed and whether it was played to its entirety. This allowed researchers to alert participants if alterations need to be made to speed or slow down the pace of program completion.

Data Analysis

Statistics

Statistical analysis was completed using STATA IC version 16.1 (StataCorps, College Station, Texas) and Microsoft Excel. The normality was visually confirmed with histogram graphs and by using the Shapiro-Wilk test. Wilcoxon signed rank test was used for non-normally distributed data. A comparison of means pre and post training were completed for all outcome measures. Scatter plots were used to depict individual baseline and post treatment scores for each outcome measure, the difference in scores and mean difference ($mean_{diff}$). For normally distributed data, Cohen's $d_{(unbiased)}$ was used to calculate effect size in order to correct for overestimation secondary to small sample size (Equation 1). For non-parametric data, effect sizes were calculated by Equation 2 where the *Z* value was an output by Wilcoxon signed rank test and *N* is the total number of observations across both baseline and post intervention.

Equation 1 Cohen's $d_{(unbiased)}$

$$\left(1-\frac{3}{\left(4(2(n-1))-1\right)}\right)\times\left(\frac{Mpre-Mpost}{\sqrt{\frac{S^2pre+\ S^2post}{2}}}\right)$$

Equation 2 Effect Size (r)

$$\frac{Z}{\sqrt{N}}$$

Ethics

The study was reviewed and approved by the George Mason Institutional Review Board (reference number at IRBNET.com 1713399-1) and registered with ClinicalTrials.gov (identifier NCT047096870). The study followed the proposed principles and guidance for ethical conduct in clinical trials established in the World

Health Organization's Clinical Health Guidelines[46] and the World Medical Association Declaration of Helsinki.[47]

Patient Safety

Participant safety was of utmost importance. Participants were educated to prioritize their safety and balance above all else. Research members provided suggestions to ensure a safe environment. Participants were encouraged to remove any tripping hazards such as rugs or moveable objects, wear supportive shoes and position themselves with the back of a chair, a countertop, or a wall within reach as they perform the intervention. Intervention videos have built-in seated exercise alternatives for the more challenging tasks. Participants received a weekly email or phone call to check safety, provide encouragement and answer any potential questions. Treatment termination or pause was permitted at the discretion of the subject.

Data Management

All digital data was password protected, secured using the online data management platform REDcap® and only accessible to the research team. All REDcap® data were stored on the secure server maintained by DSHI (the Center for Discovery Science and Health Informatics), which is HIPAA compliant. Information contained in the database spreadsheet is identifiable only by a unique identification number. Team members ensured subject privacy by conducting all virtual assessments and follow up phone calls in a designated private room outside the line of sight of others not on the research team. Subjects were free to choose their preferred location to complete all videos and interactions with investigators.

Restrictions

Due to the COIVD-19 pandemic all assessments and the intervention were completed online. It is important to note that these outcome measures were not validated for virtual administration.

RESULTS

Baseline Demographics

Of the forty-two individuals screened in response to recruitment efforts, twenty-nine participants were enrolled in the study. Five were further excluded from the study due to noncompliance of intervention protocol and two withdrew their enrollment citing computer proficiency difficulty. Overall, twenty-two participants completed the 24-session intervention protocol, seventeen females and five males with a mean age of 75.95± 3.55. Participant demographics are presented in Table 1. On average the program was completed in 50.09 days [range 48-64 days] and the average time from baseline assessment to post-intervention assessment was 62.91 days [range 50-71 days].

Table 1 Participants' Self-reported Demographic Information

Characteristic	Value
Average Age [range]	75.95 years [65-80]
Biological Sex, female/male	17/5
Ethnicity (white/non-white)	29/0
Race (Non-Hispanic/no reply	26/3
Highest Level of Education	
Attended college, did not graduate	1
College Graduate	4
Completed Graduate School/Advanced Degree	17
Assistive Device for Ambulation	
None	17
Cane	2
Did not indicate	3
Home Environment	
Spouse/Alone	14/8
Home Type	
Congregate Independent Living Facility	15
Private Residence with Study Access	7

Reaction Time

Table 2 illustrates a decline in mean reaction time for both the simple (RTS) and choice (RTC) task. Individual and group changes are presented in Figure 4. A decline in reaction time is indicative of improvement in the task. Participants were able to respond to the visual stimuli faster post intervention, with RTC showing a greater decline. RTS did not have a notable effect (r= 0.073), however RTC demonstrated a small effect post intervention with r=0.298. Participants' reaction time data during RTS and RTC were not normally distributed, therefore were treated as non-parametric data, effect sizes (ES) were calculated using Wilcoxon signed rank test.

Table 2 RT, DS, LNS: Baseline and Post-Intervention

	RTS ms		RTC ms		DS-f # correct		DS-bk # correct		LNS # correct	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
Mean	318.64	307.68	650.36	612.86	8.73	9.27	7.23	7.77	9.05	9.62
SD	38.22	55.67	124.24	102.16	2.75	2.49	2.09	2.35	3.15	2.52
CI [95%]	[301-335.95]	[283-332.36]	[595.28-705.45]	[567.77-658.16]	[7.5-9.94]	[8.17-10.38]	[6.3-8.15]	[6.73-8.81]	[7.53-10.47]	[8.47-10.76]
Mean $_{diff}$	-10.95		-37.50		0.55		0.55		0.57	
CI [95%]	[-35.86-13.95]		[-80.58-5.58]		[-0.23-1.33]		[-0.37-1.56]		[-0.72-1.96]	
Effect Size	0.073		0.298*		0.201*		0.236*		0.206*	

(*) Small Effect

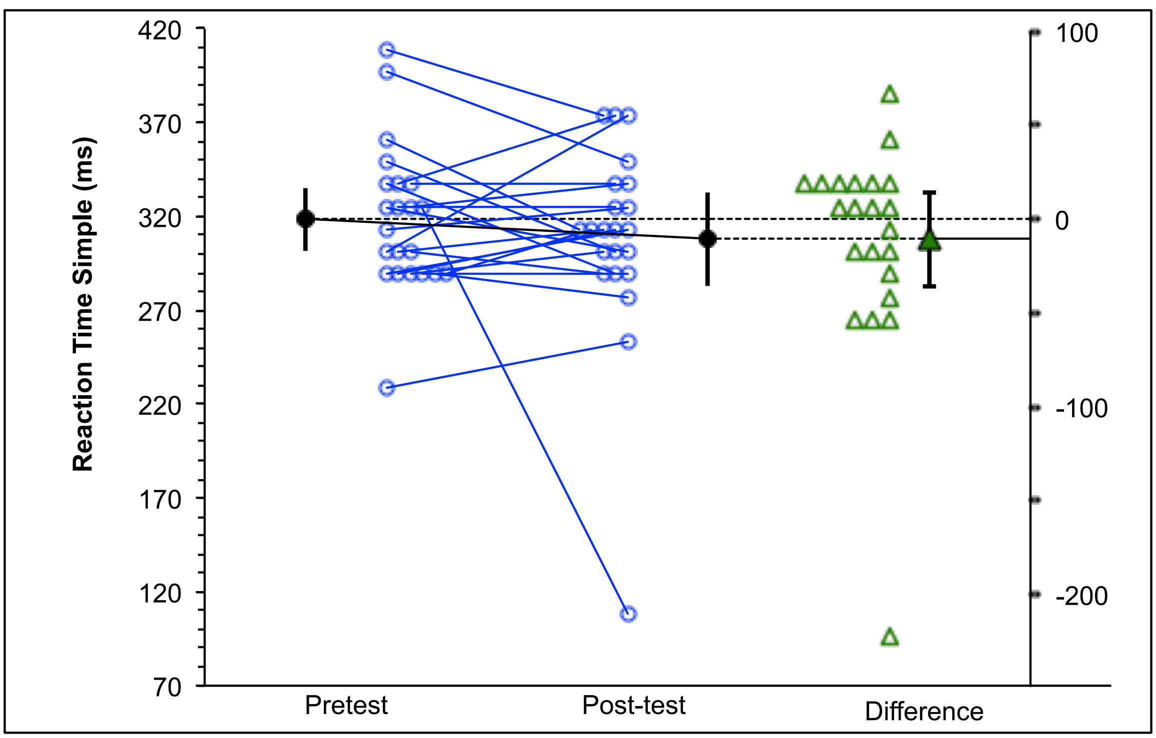


Figure 5 Reaction Time (a) Simple

Results for individual and groups changes in RTS (a) and RTC (b) in milliseconds. Individual changes are presented in hollow blue circles connected by a solid blue line. Individual changes from baseline are presented with green hollow triangles. Mean change and confidence intervals are presented as solid black circle and solid green triangle connected by solid black lines.

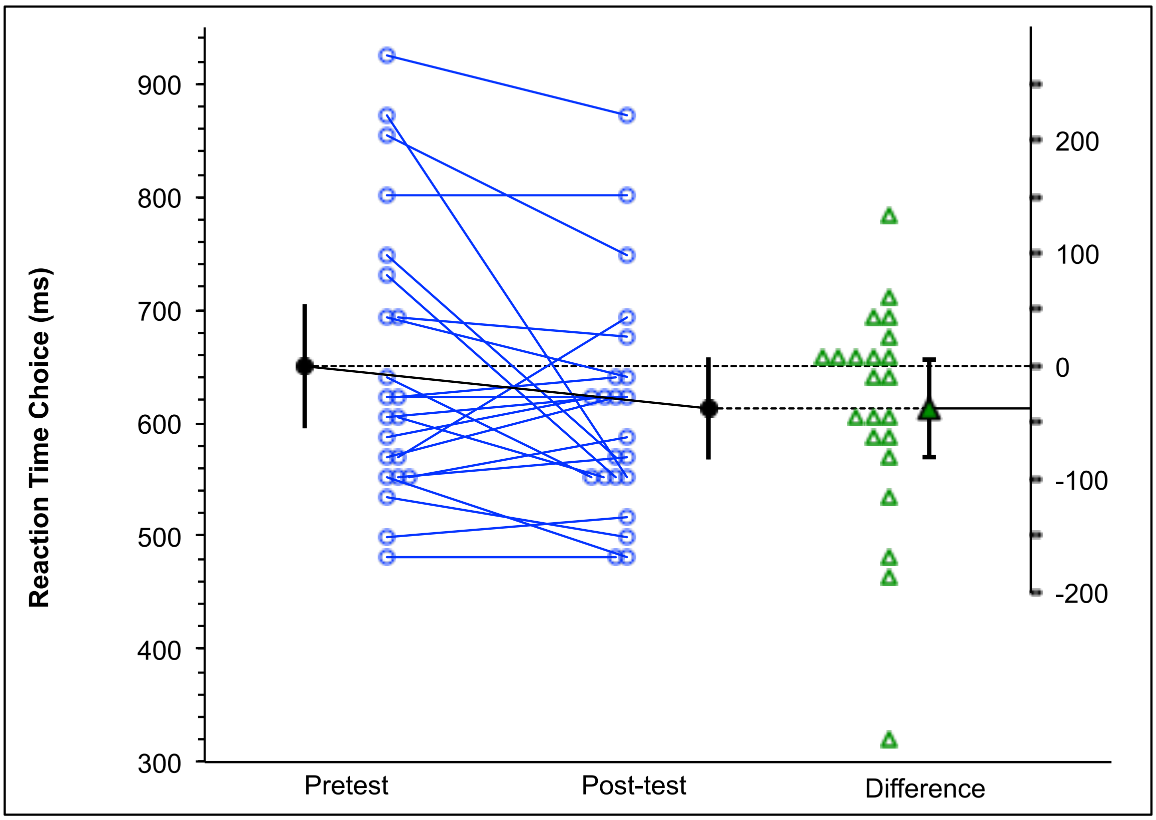


Fig. 5 (b) Choice Reaction Time

Digit Span

Overall there was an increase in the mean score and mean difference in both the forward and backwards digit span (Table 2). For the DS-f 11 participants increased their score and

9 increased for the DS-bk. An increase in DS-f score is indicative of improvement in attention and verbal passive working memory.[42] An increase in DF-bk score is indicative of improvement in verbal active working memory.[42] Small effects were observed for DS-f (Cohen's $d_{(unbiased)}$ = 0.201) and DS-bk (Cohen's $d_{(unbiased)}$= 0.236). Individual and group changes are presented in Figure 5. Scores are reported as total number of correct answers.

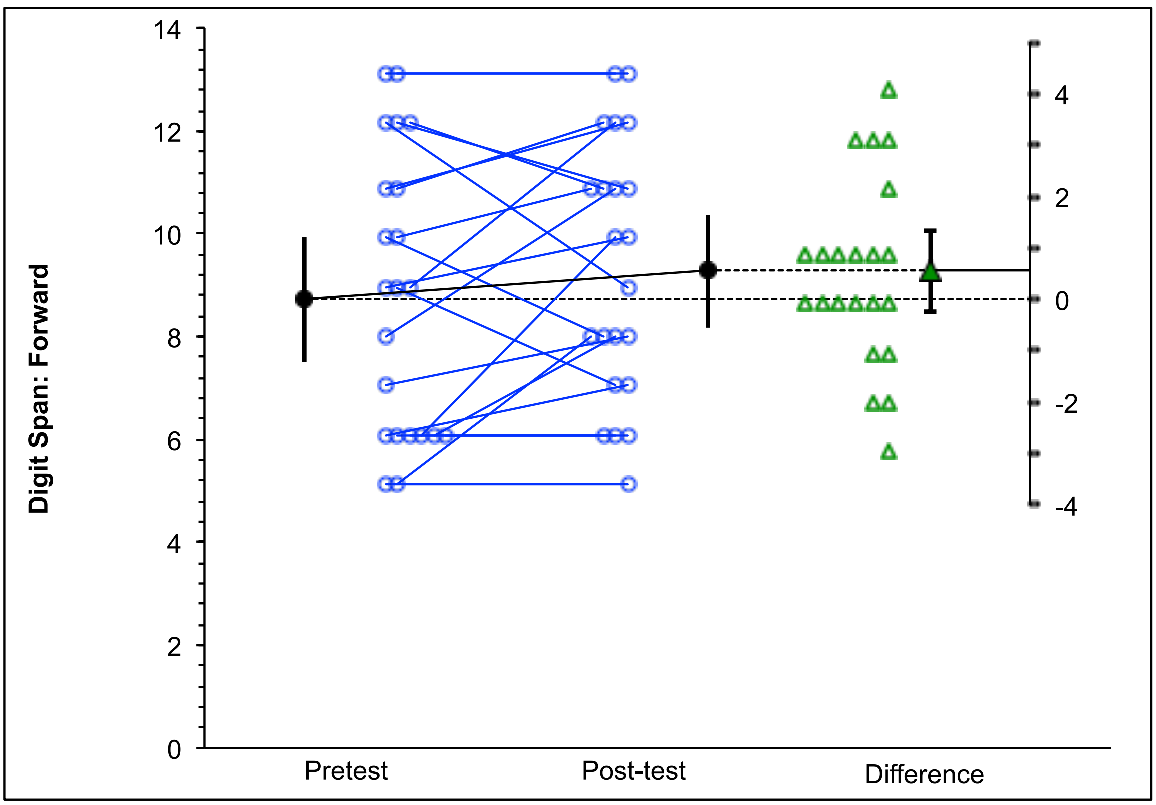


Figure 6 Digit Span (a) Forward

Results for individual and groups changes in digit span forward (a) and digit span backwards (b). Individual changes are presented in hollow blue circles connected by a solid blue line. Individual changes from baseline are presented with green hollow triangles. Mean change and confidence intervals are presented as solid black circle and solid green triangle connected by solid black lines. The maximum raw score is 14, seen on the left y-axis and the longest span for DS-f span is 9 and for the DS-bk is 8.

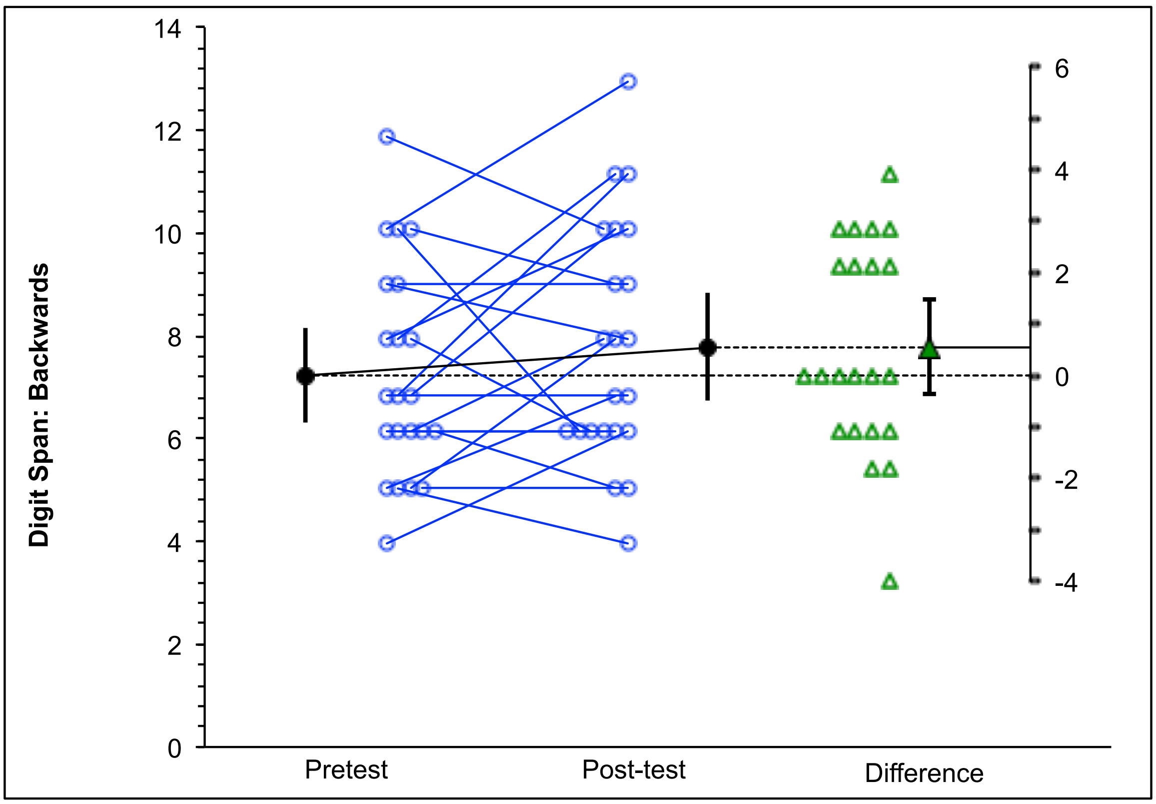


Fig. 6 (b) Backwards Digit Span

Letter Number Sequencing

Post intervention, nine participants increased their score; this is reflected in an increase in the mean score and mean difference (Table 2) and a small effect was observed (Cohen's $d_{(unbiased)}$= 0.206). Individual and group changes are presented in Figure 6. Scores are reported as total number of correct answers. The maximum raw score is 21, seen on the left y-axis and the longest span for the LNS is 8.

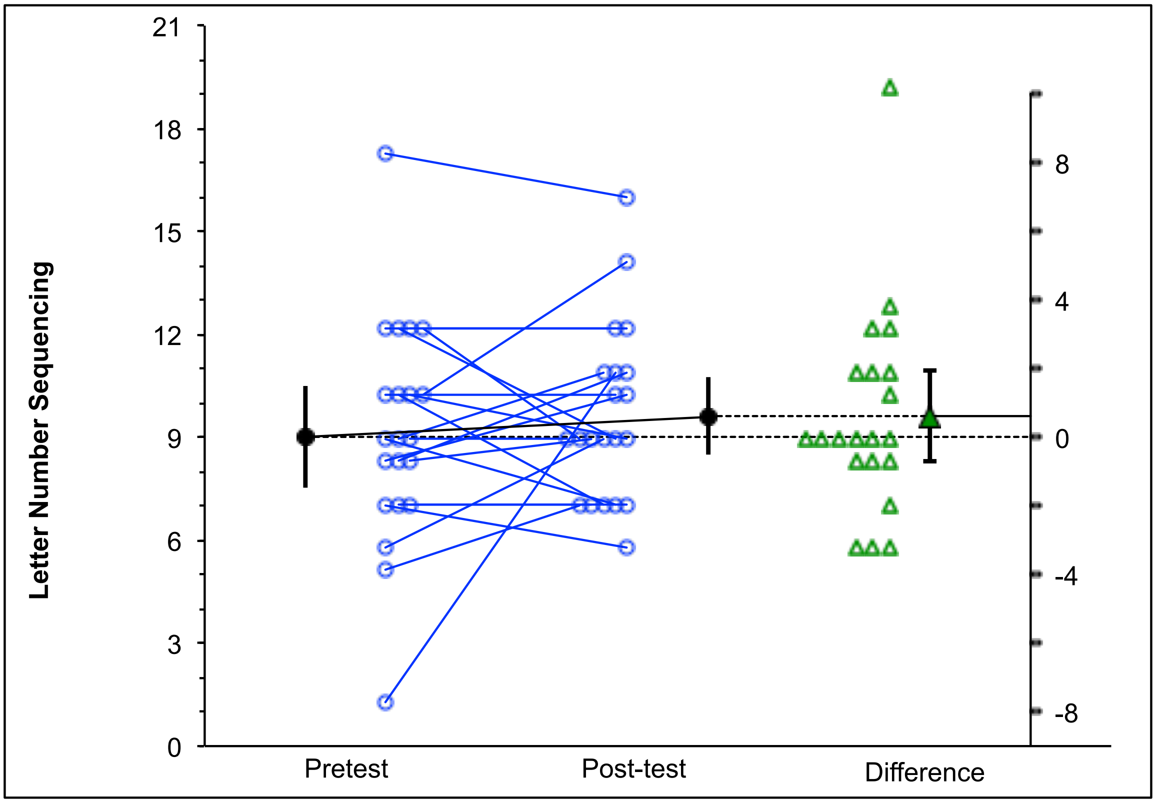


Figure 7 Letter-Number Sequencing

Results for individual and group changes in letter number sequencing. Individual changes are presented in hollow blue circles connected by a solid blue line. Individual changes from baseline are presented with green hollow triangles. Mean change and confidence intervals are presented as solid black circle and solid green triangle connected by solid black lines.

Spatial Addition

As a total group (fig. 7a) no increase in mean score was observed post intervention. However, the data were further grouped by baseline performance (low performers ≤ 10, high performers >10). This cut off was based empirically on where errors tended to occur in this sample, ascertained by visual inspection of the data. Following BAB, increase in mean score and mean difference was present in the low performers (fig.7b) and small effect (Cohen's $d_{(unbiased)} = 0.27$) was observed (Table 3). Baseline high performers (fig.7c) showed a decline in mean score post treatment. These results suggest that, for this age group, those with lower performance of VSWM responded to the intervention, whereas those with high performance VSWM were non-responders. When looking further into whether group demographics may have impacted the results, there were no sex, age or educational differences found between the high and low performers. Additionally, there were no clear consistencies or patterns between the high or low performers in VSWM and their baseline scores for the remaining auditory working memory assessments. Individual and group changes are presented in Figure 6. Scores are reported as total number of correct answers.

Table 3 Spatial Addition: Baseline and Post-Intervention

	SA Total # correct		SA Low Performers # correct		SA High Performers # correct	
	Pre	Post	Pre	Post	Pre	Post
Mean	10.72	9.72	8.8	9.4	13.13	10.13
SD	2.76	3.01	0.92	2.67	2.36	3.52
CI [95%]	[9.35-12.01]	[8.23-11.21]	[8.14-9.46]	[7.49-11.31]	[11.15-15.1]	[7.18-13.07]
Mean $_{diff}$	-1.00		0.60		-3.00	
CI [95%]	[-2.64-0.64]		[-1.61-2.81]		[-4.99- (-1.00)]	
Effect Size	0.299^{+}		0.27*		0.82^{+}	

(*) Small Effect Size, ($^{+}$) negative effect

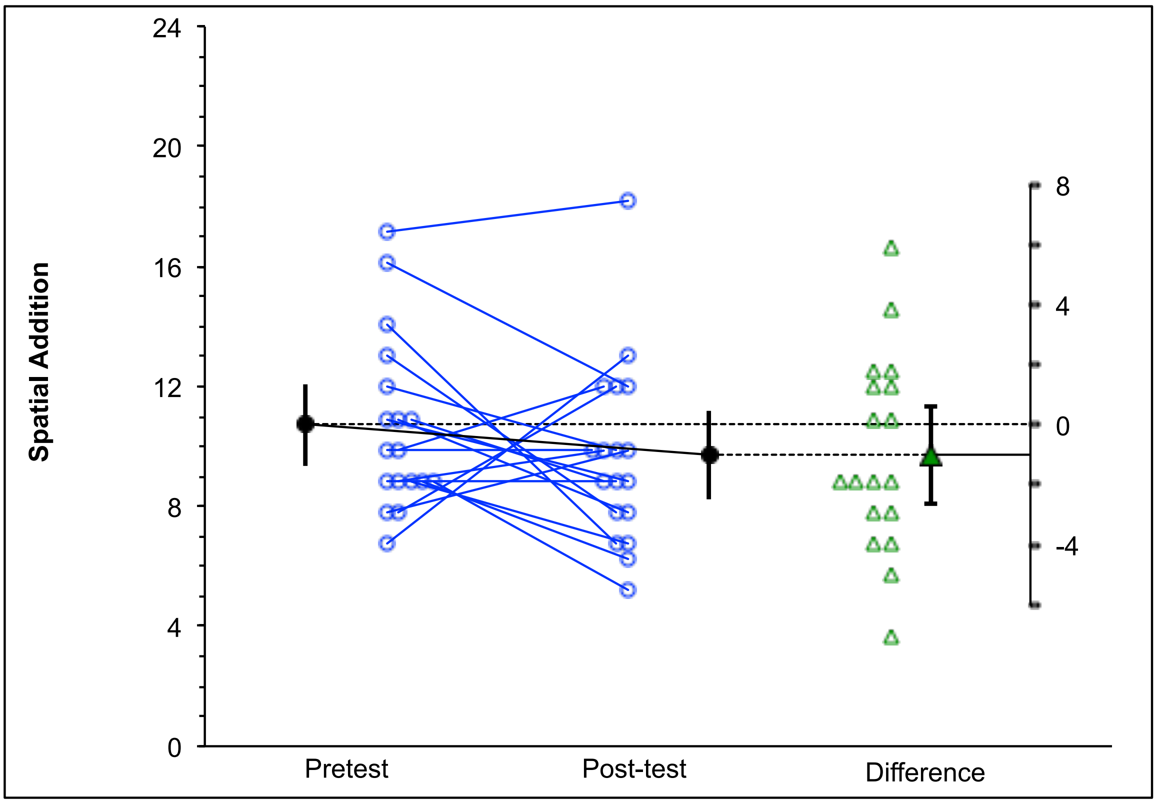


Figure 8 Spatial Addition (a) Total Subjects

Results for individual and groups changes spatial addition (a) total subjects (b) subjects with baseline score ≤ 10 (c) subjects with baseline score >10. Individual changes are presented in hollow blue circles connected by a solid blue line. Individual changes from baseline are presented with pink hollow triangles. Mean change and confidence intervals are presented as solid black circle and solid pink triangle connected by solid black lines.

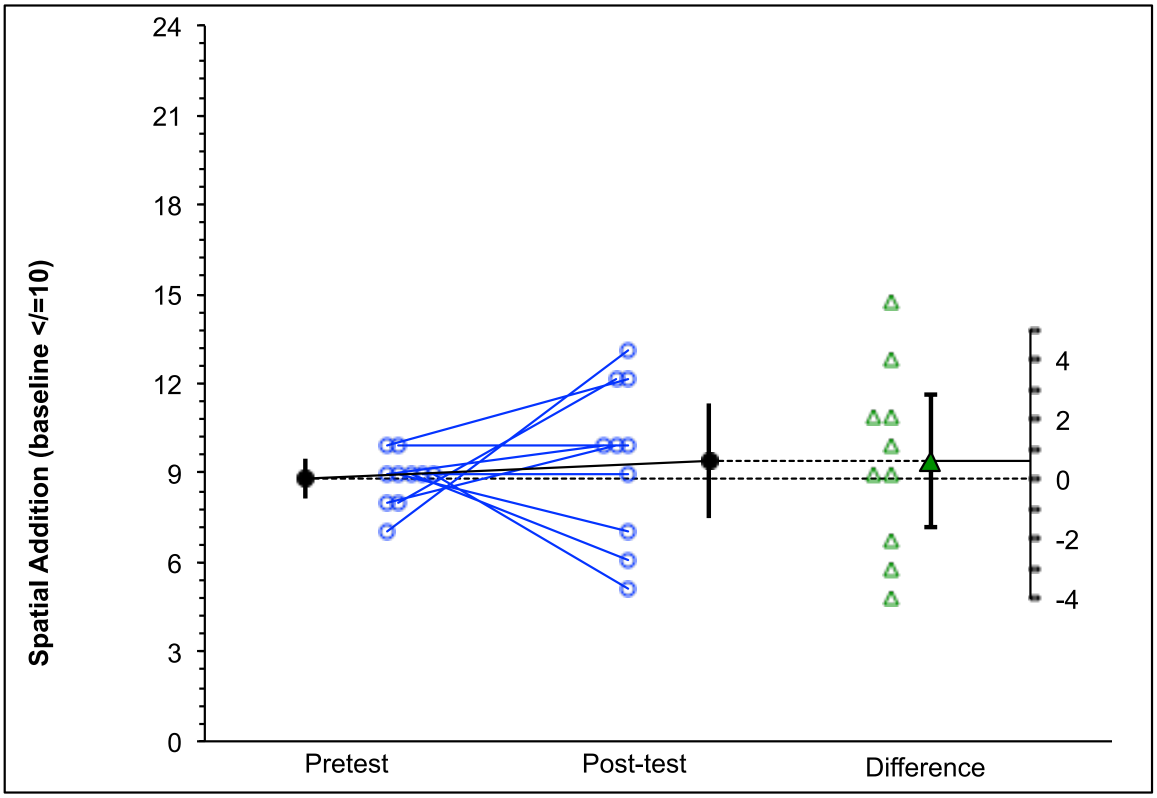


Fig. 8 (b) Low baseline score

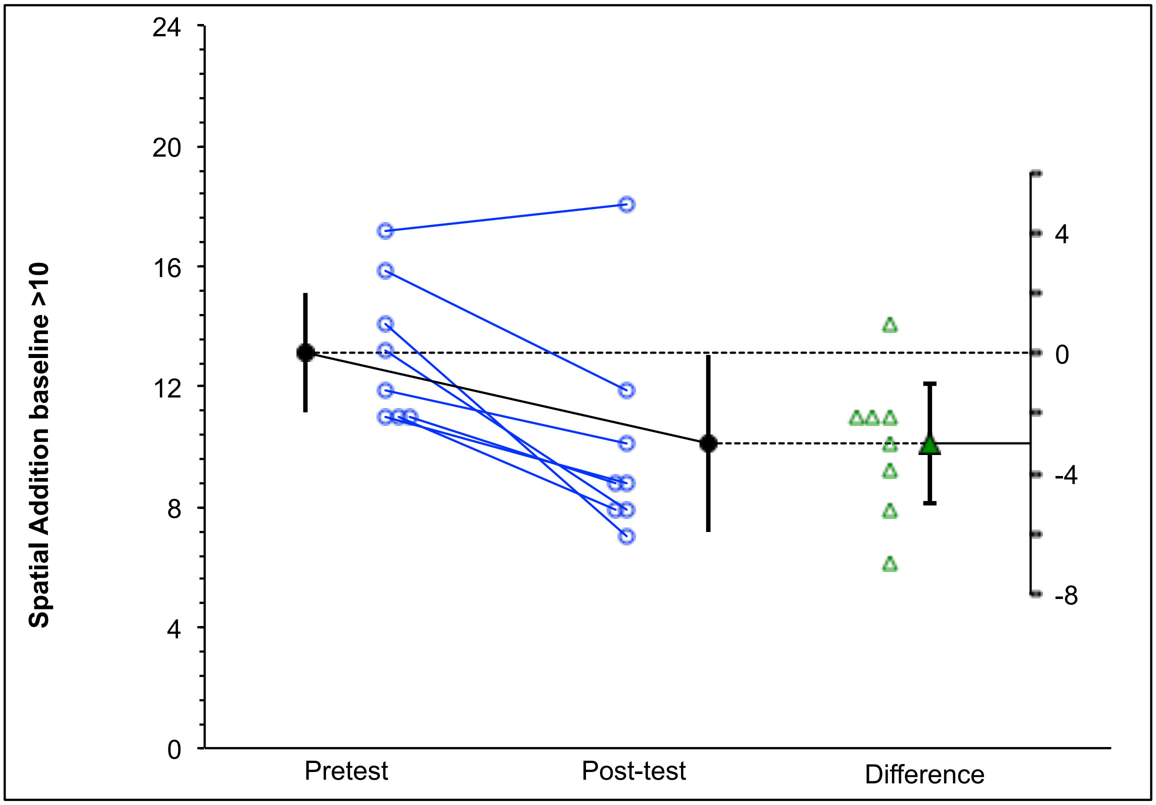


Fig. 8 (c) High baseline score

DISCUSSION

The aim of this study was to investigate the effects of a 30-minute, 3x/week, 24-session at home online movement and cognitive exercise program on cognitive performance in community-based adults and older adults. The results of this study suggest support for the hypotheses that completion of the BAB program may increase attention, auditory working memory, and processing speed in healthy older adults. However, the hypothesis that VSWM, as measured by the spatial addition task, would increase following the BAB program was only supported in those who performed low baseline scores.

Processing Speed

The data demonstrated small sized effects (Wilcoxon signed rank $r= 0.298$) for the RTC indicating a mild change from baseline. Reaction time has long been used as a proxy measure for processing speed.[48,49] Deary and Der [50,51] found that reaction time declines with age, beginning in adulthood and accelerating in mid adulthood. They found this to be especially true in choice reaction time. Our data showed no effect post-intervention for the simple reaction time task, while the choice reaction showed small effect. These results are consistent with what Deary et al[14] presented for individuals aged 61-80 years old. Our study's baseline [318.64 (38.22)] and post intervention [307.68(55.67)] values were close to to aged matched reference values for the SRT task

[296.1 (63.9)] given by Deary et al. Therefore reaching the threshold to demonstrate substantial improvement was much more difficult as this sample may already be at a high level of cognitive function in this domain. However, post intervention, the small effect in the CRT task average [612.86(102.16)] improved, trending towards the reported aged matched values [543.2 (85.3)]. It is noteworthy to mention that the mean age in our study was older at 75.9, while the mean age for values reported by Deary et al was 69.1. This is important in that cognitive domains are negatively affected by age. With an almost 7 year difference in mean age, our sample's score should arguably be below the reported reference mean. Therefore it is plausible that our sample population consisted of high performers in their older age group, muting the intervention response.

Attention

The literature consistently supports a decline in the attention domain of executive function in older age [52–54] as measured by the DS-f.[55] The data demonstrated small sized effects (Cohen's $d_{(unbiased)} = 0.201$) for the digit span forward indicating a very modest change from baseline in attention. Of note, the baseline (*mean* = 8.73) and post-intervention (mean= 9.27) raw score results in our study are near the age and educationally matched normative values (mean =10) regularly reported and used as reference data points.[11,52,53,56] This would be indicative of a relatively high performing sample population that is functioning near average in this cognitive domain. Even as already high functioning adults, the BAB program was able to elicit mild improvement post-intervention.

Working Memory

Working memory was assessed in two subdomains, auditory and visual spatial, as these are at risk for decline in the aging population.[15,16,57] Our study showed small effects (Cohen's $d_{(unbiased)}$ = 0.236) for the digit span backwards and letter number sequencing (Cohen's $d_{(unbiased)}$ = 0.206), indicating a very modest change from baseline in auditory working memory. Like the forward digit span, the mean baseline scores for the DS-bk (7.23) and LNS (9.05) were near or above the age and educationally matched normative values, DS-bk 8 and LNS 8.[12,52,53,58,59] This would again be indicative of a high performing sample, therefore the threshold to elicit statistically significant change was arguably more difficult to reach. Despite the limited room for growth within the age-matched norms, these baseline high-functioning adults demonstrated some improvement post-intervention.

Furthermore, visual spatial working memory was assessed using the spatial addition task. As a group the mean difference was -1, indicative of a decline in VSWM post intervention. However, when assessing low versus high baseline performers, the change in low performers was a small effect (Cohen's $d_{(unbiased)}$ = 0.27), suggesting a very modest improvement in VSWM. However, the high baseline performers showed a decline in VSWM, complicating interpretation of the findings. The decline post-intervention in the high performers for the spatial addition task can be viewed as regression towards the mean.

To further elucidate these results we examined if there were any sex differences. The literature is mixed on the effect of gender on working memory tasks. However, most recently a study by Piccardi et al concluded that gender differences are generally not present for auditory working memory tasks but do emerge in visual spatial tasks.[42] However, educational level and age are highly correlated with sex differences and since our sample was homogenous in these areas, it removes any possible sex effects[42] and confirms our findings of no gender differences in this sample.

It is possible that given the mean baseline score for all the outcome measures were at or above their respective age-matched norms, participants were already operating at a high functioning capacity. For cognitive gains, baseline cognitive performance has been shown to be a consistent predictor; this is especially true for individuals with low baseline cognitive performance.[60–62] Shaw and Hossenini further explain this phenomenon stating those individuals with high baseline performance or who are younger in age show less benefit as they are already functioning near their optimal level and have less room for improvement.[61] This is often viewed as a potential limitation for neurological plasticity.[63] Furthermore, education is a known positive moderator of cognitive performance throughout a lifetime.[9] Zahodne et al report that higher cognitive level and slower cognitive decline is associated with more years of education.[64] This further paints our sample population of one that may have been at their peak cognitive level as seventeen of the twenty-two individuals reported completing graduate school or having an advanced degree.

Finally, the muted results or negative observations can also be result of those individuals being assessed during the reorganization phase of learning. Much like physical training, periodization principles can work similarly in which there are peaks of optimal performance post training[65]. The variation in outcomes cannot be fully appreciated since this study did not repeat the assessments throughout the duration of the intervention.

Future studies are necessary to support our findings and provide further detail on intensity, duration and frequency in order to maximize cognitive performance gains. Additionally, a more educationally heterogeneous sample may prove to provide further generalizability.

LIMITATIONS

Since this was an independent at-home based exercise program, we could not independently confirm that subjects truly completed each video. Specific parameters for exercise remain unknown such as absolute dosing, intensity, duration and frequency. Magnitude of effect cannot be determined without a control group.

Generalizability is limited only to those with access to the Internet, have basic computer and English proficiency. Sampling bias cannot be ruled out, as those with intact cognition may have been more inclined to participate in the study. Furthermore, the overwhelm majority of participants held advanced degrees and were predominantly advanced in age, two known moderators of cognitive performance. Therefore volunteers may not be representative of the general population.[66]

Despite over 75% retention rate and verbal encouragement during the assessments, we cannot rule out the effect of participant effort on the outcome measures. It is recommended that effort indicators be used during cognitive assessments to increase the accuracy of assessments of response bias.[67] Furthermore it is important to note that these outcome measures were not validated for virtual administration. However, due to the complexity of the instruments used for pre and post intervention assessment testing a training effect is reasonably unlikely to have occurred.

CONCLUSION

These study findings trend in the direction of improvement for high functioning adults after eight weeks of participation in an online dual movement and cognitive training program. The preliminary data suggests small improvements in processing speed, working memory and attention. Furthermore this study takes an important step towards demonstrating the safety and feasibility of using an online platform to deliver specialized, complex and progressively challenging movement and cognitive program to a growing population demographic. This is important for reaching rural communities outside the metropolitan area and as healthcare moves farther towards digitalization with telemedicine rapidly gaining in popularity.

APPENDIX

Dissertation Proposal

DEPARTMENT OF REHABILITATION SCIENCE DISSERTATION COMMITTEE AND PROPOSAL APPROVAL FORM

Student: LOBNA S. ELSARAFY

Proposal Title: THE EFFECTS OF AN ONLINE MOVEMENT AND COGNITIVE DUAL TASK TRAINING PROGRAM FOR COMMUNITY-BASED ADULTS AND OLDER ADULTS ON EXECUTIVE FUNCTION: A PILOT STUDY

Proposed Committee:

________________________________ Rosemary D. Higgins, MD, Chair

________________________________ Andrew A. Guccione, PT, PhD, DPT, FAPTA, Co-Chair

________________________________ Hua Min, PhD, Committee Member

________________________________ Leah M. Adams, PhD., Committee Member

________________________________ Julie D. Ries, PT, PhD, External Reader

_ ___________________________________ Rosemary D. Higgins, MD, Interim Department Chair

Date: ___August 5, 2021_______________ Summer 2021
George Mason University
Fairfax, VA

Dissertation Proposal
By: Lobna Elsarafy

The effects of simultaneous physical activity and cognitive training (*Power Braining)* on cognitive performance in community dwelling adults and older adults

ABSTRACT

Objective: To examine the effects of a 30-minute, 3x/week, 24-session at home online mobility and cognitive exercise program for community-based adults and older adults.

Background: Cognitive performance is known to decline over time. Essential for functional independence through the aging process, cognitive performance can determine whether an individual has the ability to live independently, drive safely, and manage medications and finances. There is a growing body of evidence supporting the use of dual physical activity and cognitive interventions to improve cognition in the aging population. No known studies have examined the impact of an online dual physical and cognitive training program on attention, visual spatial working memory and processing speed.

Methods: Participants who are between the ages of 55-80 years old will be recruited from the greater Washington, D.C area, including adult independent living facilities. This study will aim for twenty total participants. Subjects will be asked to complete a total of 24 training sessions, 2-3 times per week for ~35 minutes each.
Outcome Measures: All participants will complete pre- and post-test measures of cognitive performance using simple and choice response time, the forward and backward digit span, letter number sequencing task and spatial addition subset of the Wechsler Memory Scale-IV.

Data Analysis: Statistical analysis will be completed using STATA IC version 16 and Microsoft Excel. Comparison of means pre and post training will be completed using a paired t-test with a significance set at level of $p \leq 0.05$. *Reaction Time* SRT and CRT mean response time and standard deviations will be calculated for each participant on both tasks and as a whole. *Digit Span* and *Letter Number sequencing* performance will be recorded as independent sub scores based on correct responses. Spatial Addition will be calculated as a process score of cumulative percentage.

SPECIFIC AIMS

Cognitive performance is unequivocally critical for maintaining functional independence, retaining the ability to live independently and effectively managing finances and medication.[15] Regrettably, cognitive performance, also, often declines with age. As the population of adults and older adults increases globally [1,2], so does the prevalence of age related cognitive decline. Physical training [68–70] and cognitive training[6,7,71] are accepted methods known to improve cognitive performance. However, generally healthy, community dwelling adults and older adults may demonstrate significant improvements in cognitive performance when engaged in a simultaneous physical and cognitive training program.[8–10]

The overarching research question of this proposal is what is the impact of a combined physical activity and cognitive training program on cognitive performance in healthy older adults as evidence by changes in memory, attention and processing speed? This will be achieved using the specific aim below and subsequent hypotheses:

Specific Aim: Describe the effects of a twenty-four, 35-minute per session online exercise program, Brain and Balance (BAB), on cognitive performance in community dwelling adults and older adults.
H1: BAB will improve attention, as measured by the Forward Digit Span subset of the Wechsler Adult Intelligence Scale version IV[11].
H2: BAB will improve auditory working memory, as measured by the Backward Digit Span subset of the Wechsler Adult Intelligence Scale version IV[11] and Letter Number Sequencing. [12]
H3: BAB will improve visual spatial working memory, as measured by the Spatial Addition subset of the Wechsler Memory Scale version IV. [13]
H4: BAB will improve processing speed, as measured by the Deary-Liewald[14] simple and four-choice reaction time task.

At the conclusion of this prospective pre-experimental study the effect of the BAB online virtual program on the cognitive performance domains of attention, auditory and visual spatial working memory and processing speed in community dwelling adult and older adults will be identified. The findings of the proposed study will realign treatment priorities and demonstrate the benefits of a dual physical and cognitive multifaceted, task specific and progressively challenging intervention as potential means to target cognition.

BACKGROUND/SIGNIFICANCE

Cognitive performance is unequivocally critical for maintaining functional independence, retaining the ability to live independently and effectively manage finances and medication.[15] Regrettably, cognitive performance, also, often declines with age. Over the last century the United States average life span has increased dramatically, previously 33 years in 1900 to 78.7 years in 2018. [72] Furthermore, adults over the age of 65 year old have rapidly increased in the United States. At 49.2 million in 2016, they represented 15.2% of the population. This is a 33% increase since 2006, compared to an increase of 5% for the under-65 population. By 2050, this demographic is estimated to reach 88.6 million.[1,2] Accompanying this population growth is the risk of increased prevalence of cognitive decline. Although variable, age-related cognitive decline is estimated to be 60% attributed to genetics. Therefore the question arises, whether there are certain environmental factors that can prevent, delay or attenuate cognitive decline?[15] Generally healthy, community dwelling adults and older adults may demonstrate significant improvements in cognitive performance when engaged in simultaneous physical and cognitive training program.[8–10] The cognitive domains commonly impacted with advanced age are memory, attention and processing speed.[15–17]

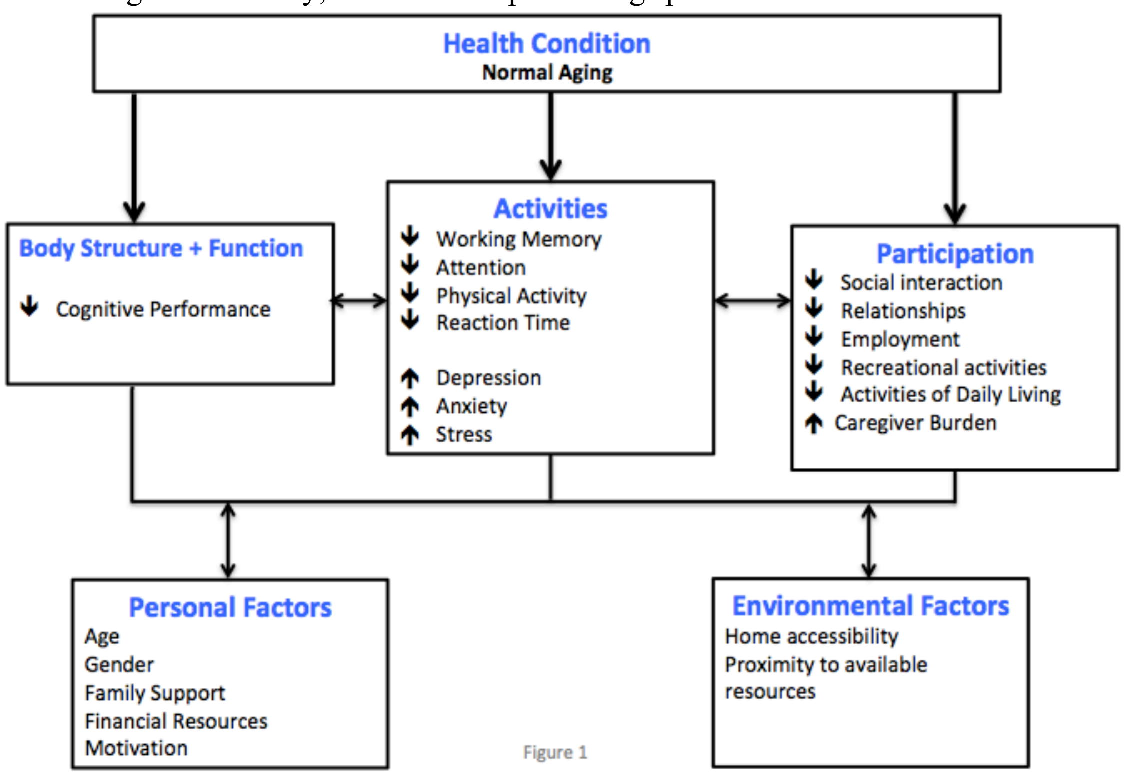


Figure 1

As the aging population increases over the next few decades it is going to be even more essential to differentiate between cognitive changes associated with aging versus pathological cognitive decline for early detection of neuropsychological conditions. Subsequently it will become critical to identify interventions that work to delay, attenuate or prevent cognitive decline. In order to understand abnormal aging, we first need to have a grasp on normal aging.

Figure 1 illustrates the theoretical framework of which this study is based using the International Classification of Functioning model.[18] The significance of the relationship between cognition and aging is shown in how a decline may affect various aspects of an individual's participation.[19] Additionally, cognitive decline may impact the individual's family and friends. Independence, functional abilities and quality of life are shown to decrease in response to a decline cognitive performance.[20] This is seen in individual withdrawal from social interaction, relationships, employment and recreation activities. In a recent study, Stites reported lower quality of life and worse psychological outcomes such as depression, anxiety, stress, and mental wellbeing in individuals who reported cognitive decline across varying degrees of cognition.[21]

The literature suggests that cognitive decline can be preventable since the brain retains plasticity, even [22–25] in older age. Bavelier and Neville operationally define *neuroplasticity* as the "capacity of the nervous system to modify it's organization to altered demands and environments".[26] Simply, this means the brain changes according to environmental input and stress. This is seen in both animal [27–29] and human studies. [8,31–33] Exercise induced changes in brain structure [34,35], neurophysiology[36,37] and function[3,38] have been well documented. These studies have shown that aerobic exercise can lead to increase cell production in the hippocampus[35], angiogenesis in the form of new capillaries in the brain and increased length and quantity of the dendritic interconnections between neurons[30,39]. These effects are likely due to increases in growth factors such as brain-derived neurotropic factor[25,35]. These structural changes enhance the brain's interconnectivity and create an environment in the central nervous system that is more plastic and adaptive to change.

The literature suggests that simultaneous physical activity and cognitive training is preferable in provoking positive changes in cognitive performance in both healthy older individuals[8–10] and those with traumatic[73] or non-traumatic[69,74] neurological events or neurological degenerative[75] disease. When cognitive performance is impaired, motor behavior becomes uncoordinated, with an inflexibility to adjust appropriately and proportionally to changes in circumstances with high distractibility.

Figure 2 illustrates how the normal aging process may lead to a decline in various aspects an individuals' life due to impairment in cognitive performance. Cognitive performance impacts many cognitive domains, however the focus of this study is on attention, working memory and processing time, which are a portion of executive functioning. When these domains are impaired, they can lead to a decline in quality of life, employment, safety, independence, and activities of daily living, life satisfaction and physical activity. Our proposed intervention of simultaneous physical and cognitive training aims to interfere with this process by directly impacting cognitive performance.

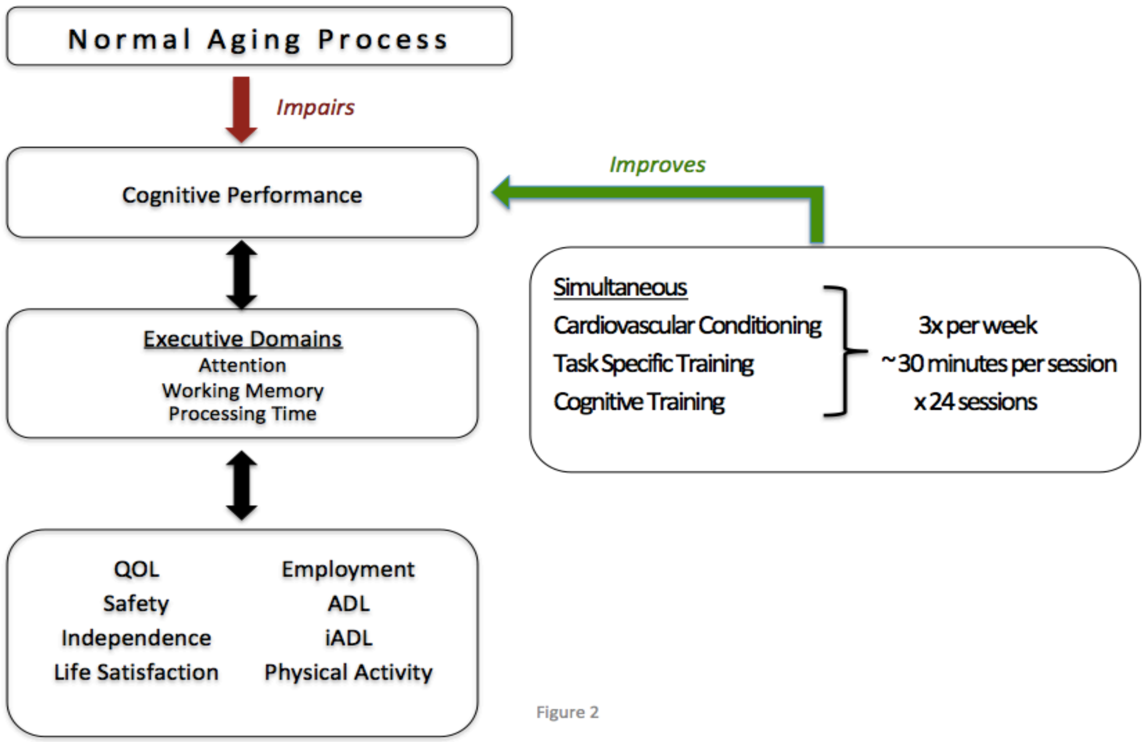


Figure 2

METHODS

Study Design Figure 3 demonstrates this one-arm 8-week prospective pre-experimental clinical trial. We propose to test the hypothesis that *Power Braining* will improve cognitive performance in community dwelling adults and older adults. Subjects cannot be blinded to the intervention because it is an exercise program that requires active participation. Subsequently the assessors cannot be blinded, as there is no equivalent sham treatment to include a control group. Blinding in this study is arguably not essential, as the purpose is to demonstrate the efficacy of the training program using objective outcome measures.

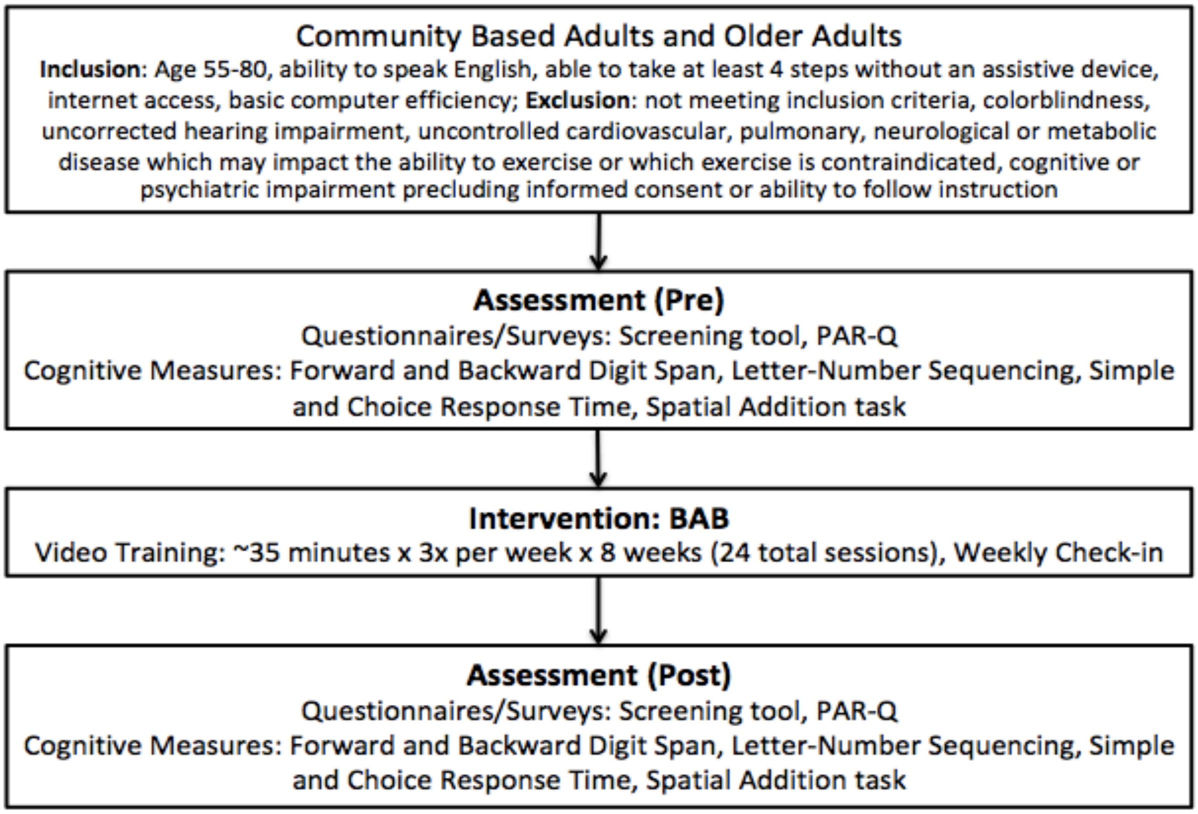


Figure 3

Target Population and Sample The target sample is twenty community dwelling adults and older adults, men and women, in generally good health, between 55-80 years of age who reside in the greater Washington, D.C area. Participants may or may not reside in an independent living facility.

Recruitment Participants will be recruited from the local community and from local independent senior living facilities in the greater Washington D.C metropolitan area through The Braining Center. Recruitment will occur using emails, flyers, word of mouth, and social media. Approval of flyer and marketing from senior independent living facilities will be sought prior to recruiting.

Participant Selection Interested participants will be instructed to email the designated study email address. Upon receipt of the inquiry, a team member will contact the participant via phone to provide a description of the study, answer questions and administer the initial screening tool to determine eligibility. Interested and eligible subjects will complete an additional screening questionnaire, the physical activity readiness questionnaire (PAR-Q).

Inclusion and Exclusion Criteria *Inclusion*: Adults between the ages of 55 to 80 years old, demonstrate the ability to take at least four steps without an assistive device, have access to the internet, are able to speak English and display basic computer proficiency. *Exclusion*: not meeting inclusion criteria, colorblindness, uncorrected hearing impairment, presence of uncontrolled cardiovascular, pulmonary, neurological, or metabolic disease (excluding obesity) which may impact the ability to exercise or in which exercise is contraindicate or have cognitive or psychiatric impairment precluding informed consent or the ability to follow instructions. Those who are ineligible or decline participation in the study will not have their responses recorded or used in the study.

Consent Procedures Participants will be initially screened via telephone conversation. After initial verbal screening participants, those who are eligible to continue will schedule a videoconference with research staff. The subject will receive an email containing a copy of the written consent form to review independently and a link to the videoconference via ZOOM. During the videoconference subjects will be provided a link to REDcap to complete the PAR-Q. The PAR-Q is used as an additional screening tool. If the subject meets all inclusion and exclusion criteria, the researcher will review the written consent form with the participant and answer any questions that arise. If the participant demonstrates understanding and is in agreement they will be asked to electronically sign the consent form. The form will be stored in the secure REDcap database and only accessible to the study investigators. Finally, the enrolled subject will be scheduled for their pre-intervention virtual assessment and provided a link to complete the online surveys.

Intervention

Content: The sessions have all previously been uploaded to a secure website. Instructions are given through auditory explanation and visual demonstration via on screen avatar. The avatar will demonstrate both the cognitive and physical tasks and complete the activity alongside the participant. The intent of the videos is to facilitate physical activity and cognitive performance improvements. To promote physical activity the exercises are structured to keep the participant in motion while maintaining an elevated heart rate using techniques such as squats, marching and upper extremity movements. The videos provide adaptations to increase or decrease the challenge based on subject ability. To promote cognitive performance, participants will be asked to complete simple and complex cognitive tasks, such as mental arithmetic, spatial memory recall and attention while completing the physical exercises. Videos are presented in a progressively challenging manner for all domains. The progression of physical tasks includes integrating narrower base of support exercises such as single leg stance or multi-planar movements versus single plane exercises. Cognitive progression is done by changing the complexity of the skill such as increasing the length of numbers in a sequence during short-term memory tasks. Additionally, cognitive complexity increases by incorporating multistep instructions such as contralateral upper extremity and lower extremity asymmetrical movements or actions. There are rest breaks and breathing exercises built in within each video to allow for recovery after the more challenging tasks.

Administration: Videos will be accessed online in the participant's home. Video completion is suggested for 2-3 times per week, with at least one rest day in between sessions. Each video is between 30-35 minutes in length and may be completed any time of day. Each participant will receive a weekly call or email to check-in on progress and answer questions.

ASSESSMENT INSTRUMENTS The following assessments will be administered virtually via Zoom platform and data will be stored on the REDcap platform. Directions will be given verbally using the specified script for each outcome measure. All assessments, except the screening tool, will be completed pre and post training within two weeks of consenting and within two weeks post intervention completion.
Screening Tool: This questionnaire is specifically designed for this study for the purpose of assessing the eligibility criteria of inquiring individuals and providing standardized information on the purpose of the study. It is administered by research staff via phone call and recorded in REDcap platform.

Deary-Liewald Task[14]: Simple and Four-Choice Reaction Time: The simple (SRT) and choice (CRT) response time tasks record reaction time, which is used to measure information processing speed. This is an online visual stimulus task. The participant will begin with the SRT and will be asked to "Wait until you see a black 'X' in the white square. When that happens, press the spacebar. The goal is to response as quickly as possible". In the CRT task there are four possible stimuli and four possible stimulus-response associations. Directions are as follows, "Wait until you see a black 'X' in one of the four white squares. When that happens, press the corresponding key (z, x, <or >). You can use both hands and may keep you fingers on the keys throughout the test. The goal is to response as quickly as possible". The SRT and CRT both allot eight practice trials, the SRT consists of twenty test trials and the CRT consists of forty test trials. The inter-stimulus interval, the time interval between each response and when the next stimulus appeared, ranged between 1 and 3 seconds and is randomized within these boundaries.

Digit Span subset of Wechsler Adult Intelligence Scale- 4th Edition (WAIS-IV): Prior to beginning this assessment each participant will complete a simple auditory assessment to ensure they are able to hear the assessor clearly. The participant will be asked to repeat these three words out loud "World, Tree, Pear". Digit Span, which has two subsections forward (DS-F) and backwards (DS-B), evaluates attention and auditory working memory respectively. The DS-F requires participants to repeat numbers in the same order as they were read aloud by the examiner. The testing administrator will say to the subject "I am going to read you a sequence of digits, and I want you to try and repeat the digits in the same order they were read out loud". To minimize confusion this example will be provided, "If I say '4, 7, 1', then you would repeat those same digits in that same order". The DS-B requires participants to repeat the numbers in reverse order of what was presented aloud by the examiner. The testing administrator will say to the subject "I am going to read you a sequence of digits, and I want you to try and repeat the digits in the reverse order they were read out loud". To minimize confusion this example will be provided, "If I say '4, 7, 1', then you would repeat those same digits backwards".

In both subsets the sequences increase in length as the participant progresses, each length has two different sequences. The DS-F has 16 sequences and the DS-B has 14 sequences. The maximum raw score of DS-F is 16 and DS-B is 14. The digits will be read in an even tone, at approximately the rate of one digit per second. The first set of sequences will begin at three digits. Discontinuation criterion is failure to correctly reproduce two sequences of equal length.

Letter-Number Sequencing (LNS) is an outcome measure, which assesses auditory working memory. The LNS requires participants to listen to a series of number and letter and repeat the sequence starting first with the numbers in ascending order, followed by the letters in alphabetical order. The testing administrator will say to the subject "I am going to say a set of numbers and letter. Your task is report them by first saying the numbers in ascending order and then the letters in alphabetical order. For example, if I say '9, T, 3, A', your response would be '3, 9, A, T'." The numbers and letters will be read in an even tone, at approximately the rate of one digit/number per second. The first sequence begins at two and increases in length as the participant progresses. The maximum raw score is 21. Discontinuation criterion is failure to correctly reproduce three sequences of equal length.

Spatial Addition subset of Wechsler Memory Scale- 4th Edition (WMS-IV): This subtest examines visual spatial working memory and will be administered using Q-global Pearson platform. To ensure that the participant does not exhibit colorblindness, he/she will be shown the response sheet, which includes a black and white grid and red, blue and white circles, and asked to verbally describe the page. During the assessment the participant is shown two 4x4 grids for five seconds each. Both stimuli grids will contain blue dots, red dots or both. The participant is required to memorize the color and spatial location of the dots in the first and second stimulus. They will then be asked to use their recollection of the color and location of those dots to create a final grid that adds the spatial locations of the blue dots, ignore any red dots and subtracts the location of blue dots that overlap. The instructions will go as follows: “In this next task, you will be shown two grids for 5 seconds each that contain red or blue dots. Your task in the third grid is to create a final grid that adds the spatial location of the blue dots, subtracting any blue dots that overlapped and ignore any red dots”. Participants will be shown an example of this task.

Although unrelated to the study additional surveys and questionnaires will be used to measure self-efficacy, physical activity and balance confidence will be collected.

DATA COLLECTION PROCEDURES

Cultural Competence This study is open to all who meet the inclusion and exclusion criteria regardless of gender, ethnicity, religious affiliations, education or sexual orientation. Due to the nature of the training program and heavy reliance on verbal instruction, conversational understanding of English is a requirement.

Treatment Fidelity Assessors will complete extensive rehearsal of all elements of data collection procedures including use of REDcap platform for data storage and questionnaire/survey administration, outcome measure administration and videoconferencing. All participants will be given access to the same intervention videos via online website with their own unique login information. Weekly check-ins via email or phone call will provide opportunity to address participant concerns or questions. Researchers will have access to Power Braining platform to collect independent data, including the videos subjects viewed, the date and time the video was viewed and whether it was played to its entirety. This will allow researchers to alert participants if alternations need to be made to the pace of video completion. However, since this is an independent at-home based exercise program, a limitation of the study is the inability to independently visually confirm that subjects truly completed each video.

DATA ANALYSIS

Statistics Statistical analysis will be completed using STATA IC version 16 and Microsoft Excel. Comparison of means pre and post training will be completed using a paired t-test with a significance set at level of $p \leq 0.05$. If the sample size is sufficiently large and meet other criteria for analysis, a one-way ANOVA between subjects will assess if level of completed education (high school, undergraduate, graduate school) or sex have a significant effect. *Reaction Time* SRT and CRT mean response time and standard deviations will be calculated for each participant on both tasks and as a whole. *Digit Span* and *Letter Number sequencing* performance will be recorded as independent sub scores based on correct responses. Spatial Addition will be calculated as a process score of cumulative percentage.

Power and Sample Size

There are no data specific to this study upon how we can appropriately base our sample size calculation. Using a table based approach on effect size, a sample as small as 36 participants will produce 80% power to detect moderate size effects (0.6) with $\alpha = 0.05$.

ETHICS The study was reviewed and approved by the George Mason Institutional Review Board (reference number at IRBNET.com 1713399-1) and ClinicalTrials.gov (identifier NCT047096870). The study will also follow the proposed principles and guidance for ethical conduct in clinical trials established in the World Health Organization's Clinical Health Guidelines[46] and the World Medical Association Declaration of Helsinki.[47]

PATIENT SAFETY

Participant safety is of utmost importance. Participants will be educated to prioritize their safety and balance above all else. Research members will provide suggestions to ensure a safe environment. Participants are encouraged to remove any tripping hazards such as rugs or moveable objects, wear supportive shoes and position themselves with the back of a chair, a countertop, or a wall within reach to their front or side as they perform the intervention. Intervention videos have built-in seated exercise alternatives for the more challenging tasks. Participants will receive a weekly email or phone call to check safety, provide encouragement and answer any potential questions. Treatment termination or pause is permitted at the discretion of the subject.

DATA MANAGEMENT All digital data will be password protected, secured using the online data management platform REDCap and only accessible to the study research team. All REDCap data are stored on the secure server maintained by DSHI (the Center for Discovery Science and Health Informatics), which is HIPAA compliant. Information contained in the database spreadsheet will be identifiable only by a unique identification number. Team members will ensure subject privacy by conducting all virtual assessments and follow up phone calls in a designated private room outside the line of sight of others not on the research team. Subjects will select a private area of their residence.

Limitations Due to the COIVD-19 pandemic all assessments will be online, it is important to note that these outcome measures were not validated via virtual administration. Specific parameters for exercise will remain unknown such as absolute dosing, intensity, duration, frequency and duration. This is usually difficult in rehabilitation treatment studies secondary to cost-effectiveness.[76] Inferences or a direct association between cognition and aerobic capacity is limited since cardiorespiratory exercise testing, the gold standard for aerobic capacity, is not used. Magnitude of effect cannot be determined without a control group. There is a chance there will be sampling bias, as those with intact cognition may be more inclined to participate in such a study, therefore volunteers may not be wholly representative of their age group. Finally, despite a minimum of 8-weeks between the pre and post assessment testing, a training effect is possible through repeated exposure to assessment tools.

Documents

Link to ClinicalTrials.gov

To view the parent study registration on ClinicalTrials.gov please use the link below:
https://clinicaltrials.gov/ct2/show/NCT04796870

Screening Tool

Please complete the survey below.

Thank you!

Introduce Yourself

"Hello, my name is _____________ from the department of Rehabilitation Science at George Mason University."

Tell them why you are calling and the purpose of the study.

"We are working on a research study to evaluate the impact of The BRAINing™ Center's "Brain & Balance" training program mobility, balance, cognition and psychological well-being in generally healthy older adults.

If you're interested in learning more, can I request your permission to ask questions to see if you qualify for this research study? The screening responses of those ineligible or who choose not to participate will neither be saved nor used in the research. "

○ Yes ○ No

If no -- thank them for their time and politely end call.
If yes -- continue below.

"We will be collecting information about you during this call. Your part on this call is completely voluntary. The information collected will only be seen by researchers on this study team. We make sure the information is kept private and is only used for this particular research study. If you do not want to continue the phone call, it will not affect any aspect of your relationship with George Mason University or you living facility."

○ Yes ○ No

If no -- thank them for their time and politely end call.
If yes -- continue below.

"To see if you are eligible for this study, is it alright if I ask you a few questions?"

○ Yes ○ No

"Are you 55 to 80 years of age?"

○ Yes ○ No

"Do you have any problems or health issues that may limit your ability to understand legal documents or multistep instructions?"

○ Yes ○ No

"Have you been diagnosed with a heart, blood, lung, vascular or metabolic condition that is not controlled by medication or a doctor's care?"

○ Yes ○ No

"Are you able to take at least 4 steps without an assistive device like a cane or a walker?"

○ Yes ○ No

Department of Rehabilitation Science
4400 University Drive, MS 2G7, Fairfax, Virginia 22030
Phone: 703-993--1950; Fax: 703-993-6073

INFORMED CONSENT

Outcomes of Powerbraining

RESEARCH PROCEDURES

This research is being conducted to understand the outcomes of a 24 session on-line mobility and cognitive exercise program for community-based adults and older adults. The primary outcomes of interest are changes in cognitive functioning and mobility, with secondary outcomes related to self-efficacy, resilience, and physical activity. If you agree to participate, you will be asked to participate in 24 online training sessions following a virtual initial assessment of your health history, readiness for physical activity, balance confidence. Training sessions will occur three times per week for eight weeks. At the conclusion of training, you will be asked to repeat your initial assessment.

Examination Procedures

You may be asked to complete the following online surveys and assessments as part of the pre- and post- training evaluations:

- Health History Questionnaire
- Physical activity readiness questionnaire
- Cognitive assessments
- Muscle strength, power, and endurance – may ask you to perform repetitive functional movements for a given period of time during a video call.
- Balance assessment– may be measured by self-report questionnaires, or virtual observation.
- Activities of daily living and leisure time physical activity – may be measured by self-report questionnaires, observation. You may be asked to perform specific movements with or without videorecording.
- Gait and Balance assessments: tests and measures of your ability to balance during static and dynamic activities.

1) Each assessment and evaluation session will last approximately 90 minutes on the same day before and following training (3 hours total). The assessment will begin with instruments located on Redcap including Health History, Physical Activity Readiness Questionnaire, International Physical Activity Questionnaire, Connor-

Davidson Resilience Scale, OPTIMAL Self-Confidence Scale, and Activities-Related Balance Confidence Scale, Digit Span, Reaction Time, and Working Memory. Balance, muscle strength and endurance tests will include the 30-Second Chair Sit-Stand Test and Four-Stage Balance.

Training Procedures

Training sessions are performed three times per week for 8 weeks. Training will occur virtually by logging onto the Powerbraining website and completing the assigned pre-recorded video. Powerbraining is a virtual exercise platform with various live and pre-recorded exercise classes. This Brain and Balance class is selected for this study. This program is a collection of exercises designed to improve mobility, balance and cognition. The program requires following an avatar trainer while simultaneously problem solving and performing various exercises. Each training session will last approximately 35 minutes, three times per week for 8 weeks. A member of the research team will reach out weekly with email and or phone call to answer questions and discuss concerns regarding training.

Videography and photography

Video and photographs may be included when disseminating research presentations at conferences and in teaching presentations. You have the right to decline videotaping and/or photography at any session or any given point while videotaping. Your videos may be used for training and teaching purposes. To the extent possible, you will be recorded in ways that will diminish facial recognition. Video material (photos and videos) will remain on a secure hard drive and deleted after five years following the study's completion. While participating in the study or after your participation has ended, you may request the immediate removal of your videotapes and photos from storage. Some tests may be recorded before and after training.

While it is understood that no computer transmission can be perfectly secure, reasonable efforts will be made to protect the confidentiality of your transmission. Participants may review Zoom for information about their privacy statement by visiting: https://zoom.us/privacy.

Re-testing Procedures

At the conclusion of 24 sessions, you will be retested with the same assessments as baseline testing.

Time Commitments

Participants will need to be available for approximately 1.5 hours of testing prior to and following training for approximately 3 total hours of testing and a total of 24 training sessions (three 35-minute sessions per week for 8 weeks). The total time commitment will be approximately 17 hours.

RISKS

The foreseeable risks or discomfort are similar to the risks you take when exercising or engaging in moderate physical activity on your own, with or without supervision, at home or in a gym or other facility. The level of exercise or physical activity is in your control. You will not be asked to engage in any activity that you believe is beyond your ability or tolerance.

You may experience some discomfort during or in hours following training that may include muscle fatigue, muscle or joint soreness, and lightheadedness. Straining a muscle or spraining a ligament is a minimal possibility during training.
You may experience a fall, slip, or trip during assessment and training. Every effort will be made to minimize these risks. If you experience any difficulties, please contact the research team immediately.

The risks of exercise training are generally low, although sometimes medical complications do occur. During exercise and moderate physical activity, specific heart rate and rhythm changes, blood pressure, and respiratory rate are expected, but abnormal or unanticipated changes are slight possibilities. Every effort will be made to minimize these risks.

Although rare in occurrence, the most severe risks of training include sudden death, heart attack, dizziness, chest pain or tingling in the arm, jaw, or back, shortness of breath, and/or extreme fatigue. Please email the research team at rhbstudy@gmu.edu if you experience any of these symptoms during or after study-related activities.
In case of life-threatening injury during training, please stop immediately and call 911. Neither George Mason University nor the investigators have funds available for medical treatment payment for injuries that you may sustain while participating in this research. Should you need medical care, you or your insurance carrier will be responsible for payment of the expenses required for medical treatment.

BENEFITS

Participants who complete study including, both assessments and all 24 training sessions, will receive a complimentary 1-year membership to Powerbraining worth $156. Participants who do not complete the study as described will be ineligible for the complimentary membership.

CONFIDENTIALITY

The data in this study will be confidential, including in publications and reports resulting from the research. All participants will be assigned a de-identified number after agreeing to participate, and all de-identified data will be stored using this identification number. The signed informed consent and the identification number linking data to individuals will be stored by the lead researcher in a locked cabinet in a locked office along with any other forms or papers that have protected personal or health information. Only members of the research team will have access to this information. The de-identified data could be used for future research without additional consent from participants. Monitors, auditors, the Institutional Review Board, and regulatory authorities may have access to the data for verification of clinical trial procedures without violating the confidentiality of the participants to the extent permitted by law.

The de-identified data could be used for future research without additional consent from participants.

The Institutional Review Board (IRB) committee that monitors research on human subjects may inspect study records during internal auditing procedures and are required to keep all information confidential.

PARTICIPATION

Your participation is voluntary, and you may withdraw from the study at any time and for any reason. If you decide not to participate or if you withdraw from the study, there is no penalty or loss of benefits to which you are otherwise entitled. There are no costs to you or any other party.

CONTACT

This research being conducted is led by Dr. Andrew Guccione, Department of Rehabilitation Science, at George Mason University. He may be reached at 703-993-4650, or aguccion@gmu.edu for questions or to report a research-related problem. You may contact the George Mason University Institutional Review Board Office at 703-993-4121 if you have questions or comments regarding your rights as a participant in the research.

This research has been reviewed according to George Mason University procedures governing your participation in this research, **IRBnet #:1713399-1**.

CONSENT

I have read this form, all my questions have been answered by the research staff, and I agree to participate in this study.
Please indicate below your preference for videography/photography. This will not affect your participation in the study.

☐ I grant permission to videotape my image and likeness as part of this research study.

☐ I DO NOT grant permission to videotape my image and likeness as part of this research study.

____
Signature

____
Date of Signature

Physical Activity Readiness Questionnaire

Please complete the survey below.

Thank you!

2017 PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

The health benefits of regular physical activity are clear; more people should engage in physical activity every day of the week. Participating in physical activity is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.

1) Has your doctor ever said that you have a heart condition?	◯ Yes ◯ No
OR has your doctor ever said that you have high blood pressure?	◯ Yes ◯ No
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	◯ Yes ◯ No
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	◯ Yes ◯ No
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)?	◯ Yes ◯ No
PLEASE LIST CONDITION(S) HERE:	
5) Are you currently taking prescribed medications for a chronic medical condition?	◯ Yes ◯ No
PLEASE LIST CONDITION(S) AND MEDICATIONS HERE:	

6) Do you currently have (or have had within the past 12 months) a bone, joint, or soft tissue (muscle, ligament, or tendon) problem that could be made worse by becoming more physically active? Please answer NO if you had a problem in the past, but itdoes not limit your current abilityto be physically active.	◯ Yes ◯ No
PLEASE LIST CONDITION(S) HERE:	
7) Has your doctor ever said that you should only do medically supervised physical activity?	◯ Yes ◯ No

If you answered NO to all of the questions above, you are cleared for physical activity. You will be taken to the end of this survey to sign the PARTICIPANT DECLARATION.

Start becoming much more physically active – start slowly and build up gradually.Follow International Physical Activity Guidelines for your age (www.who.int/dietphysicalactivity/en/).You may take part in a health and fitness appraisal.If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.If you have any further questions, contact a qualified exercise professional.

If you answered YES to one or more of the questions above, COMPLETE THE NEXT SECTION.

Delay becoming more active if:

You have a temporary illness such as a cold or fever; it is best to wait until you feel better.You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active.Your health changes - answer the questions below and/or talk to your doctor or a qualified exercise professional before continuing with any physical activity program.

2017 PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?	◯ Yes ◯ No
1a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	◯ Yes ◯ No
1b. Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	◯ Yes ◯ No

1c. Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	◯ Yes ◯ No
2. Do you currently have Cancer of any kind?	◯ Yes ◯ No
2a. Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and/or neck?	◯ Yes ◯ No
2b. Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	◯ Yes ◯ No
3. Do you have a Heart or Cardiovascular Condition? (This includes Coronary Artery Disease, Heart Failure, Diagnosed Abnormality of Heart Rhythm.)	◯ Yes ◯ No
3a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	◯ Yes ◯ No
3b. Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	◯ Yes ◯ No
3c. Do you have chronic heart failure?	◯ Yes ◯ No
3d. Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	◯ Yes ◯ No
4. Do you have High Blood Pressure?	◯ Yes ◯ No
4a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	◯ Yes ◯ No
4b. Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer YES if you do not know your resting blood pressure)	◯ Yes ◯ No
5. Do you have any Metabolic Conditions? (This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes.)	◯ Yes ◯ No
5a. Do you often have difficulty controlling your blood sugar levels with foods, medications, or other physician prescribed therapies?	◯ Yes ◯ No

5b. Do you often suffer from signs and symptoms of low blood sugar (hypoglycemia) following exercise and/or during activities of daily living? Signs of hypoglycemia may include shakiness, nervousness, unusual irritability, abnormal sweating, dizziness or light-headedness, mental confusion, difficulty speaking, weakness, or sleepiness.	◯ Yes ◯ No
5c. Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, OR the sensation in your toes and feet?	◯ Yes ◯ No
5d. Do you have other metabolic conditions (such as current pregnancy-related diabetes, chronic kidney disease, or liver problems)?	◯ Yes ◯ No
5e. Are you planning to engage in what for you is unusually high (or vigorous) intensity exercise in the near future?	◯ Yes ◯ No
6. Do you have any Mental Health Problems or Learning Difficulties? (This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome.)	◯ Yes ◯ No
6a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	◯ Yes ◯ No
6b. Do you have Down Syndrome AND back problems affecting nerves or muscles?	◯ Yes ◯ No
7. Do you have a Respiratory Disease? (This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure.)	◯ Yes ◯ No
7a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	◯ Yes ◯ No
7b. Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	◯ Yes ◯ No
7c. If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	◯ Yes ◯ No
7d. Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	◯ Yes ◯ No

8. Do you have a Spinal Cord Injury? (This includes Tetraplegia and Paraplegia.)	○ Yes ○ No
8a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	○ Yes ○ No
8b. Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	○ Yes ○ No
8c. Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	○ Yes ○ No
9. Have you had a Stroke? (This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event.)	○ Yes ○ No
9a. Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer NO if you are not currently taking medications or other treatments)	○ Yes ○ No
9b. Do you have any impairment in walking or mobility?	○ Yes ○ No
9c. Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	○ Yes ○ No
10. Do you have any other medical condition not listed above or do you have two or more medical conditions?	○ Yes ○ No
10a. Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months OR have you had a diagnosed concussion within the last 12 months?	○ Yes ○ No
10b. Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	○ Yes ○ No
10c. Do you currently live with two or more medical conditions?	○ Yes ○ No
PLEASE LIST YOUR MEDICAL CONDITION(S) AND ANY RELATED MEDICATIONS HERE:	________________________________
Continue for recommendations about your current medical condition(s).	

If you answered NO to all of the follow-up questions about your medical condition,You are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

It is advised that you consult a qualified exercise professional to help you develop a safe and effective physical activity plan to meet your health needs. You are encouraged to start slowly and build up gradually - 20 to 60 minutes of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises. As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week. If you are over the age of 45 yr and NOT accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional before engaging in this intensity of exercise.

If you answered YES to one or more of the follow-up questions about your medical condition:

You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the ePARmed-X+ at www.eparmedx.com and/or visit a qualified exercise professional to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

You have a temporary illness such as a cold or fever; it is best to wait until you feel better. You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the ePARmed-X+ at www.eparmedx.com before becoming more physically active. Your health changes - talk to your doctor or qualified exercise professional before continuing with any physical activity program.

You must use the entire questionnaire and NO changes are permitted. The authors, the PAR-Q+ Collaboration, partner organizations, and their agents assume no liability for persons who undertake physical activity and/or make use of the PAR-Q+ or ePARmed-X+. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

Warburton, D. E., Jamnik, V. K., Bredin, S. S. D., Shephard, R. J., & Gledhill, N. (2017). The 2017 Physical Activity

Readiness Questionnaire for Everyone (PAR-Q+) and electronic Physical Activity Readiness Medical Examination (ePARmed-X

Demographics

Please complete the survey below.

Thank you!

Participant Information

First name	__________________
Last name	__________________
Email address	__________________
Phone number	__________________
Date of Birth	__________________
Age	__________________
Sex	◯ Male ◯ Female
Race (check all that apply)	☐ American Indian/Alaska Native ☐ Native Hawaiian or Other Pacific Islander ☐ Black or African American ☐ Asian ☐ White (including Middle Eastern) ☐ Other ☐ Decline

Ethnicity

◯ 1) Hispanic or Latino
◯ 2) Not Hispanic or Latino

Education (Please check one)

◯ 1) Less than high school
◯ 2) Some high school
◯ 3) High school graduate
◯ 4) Attended or graduated from technical school
◯ 5) Attended college, did not graduate
◯ 6) College graduate
◯ 7) Completed graduate school/advanced degree

Employment/Work (Check all that apply)

☐ 1) Working full-time outside of home
☐ 2) Working part-time outside of home
☐ 3) Working full-time from home
☐ 4) Working part-time from home
☐ 5) Working with modification in job because of current illness/injury
☐ 6) Not working because of current illness/injury
☐ 7) Homemaker
☐ 8) Student
☐ 9) Retired
☐ 10) Unemployed

Do you use a: (Check all that apply)

☐ 1) Cane?
☐ 2) Walker, rolling walker, or rollator?
☐ 3) Manual wheelchair?
☐ 4) Motorized wheelchair?
☐ 5) Other:
☐ 6) None

Other: ________________________________

With whom do you live? (Check all that apply)

☐ 1) Alone
☐ 2) Spouse/significant other
☐ 3) Child/children
☐ 4) Other relative(s)
☐ 5) Group setting
☐ 6) Personal care attendant
☐ 7) Other:

Other: ________________________________

Where do you live?

◯ 1) Private home
◯ 2) Private home with at-home community benefits
◯ 2) Private apartment
◯ 3) Rented room
◯ 4) Board and care/assisted living/group home
◯ 5) Homeless (with or without shelter)
◯ 6) Long-term care facility (nursing home)
◯ 7) Hospice
◯ 8) Other

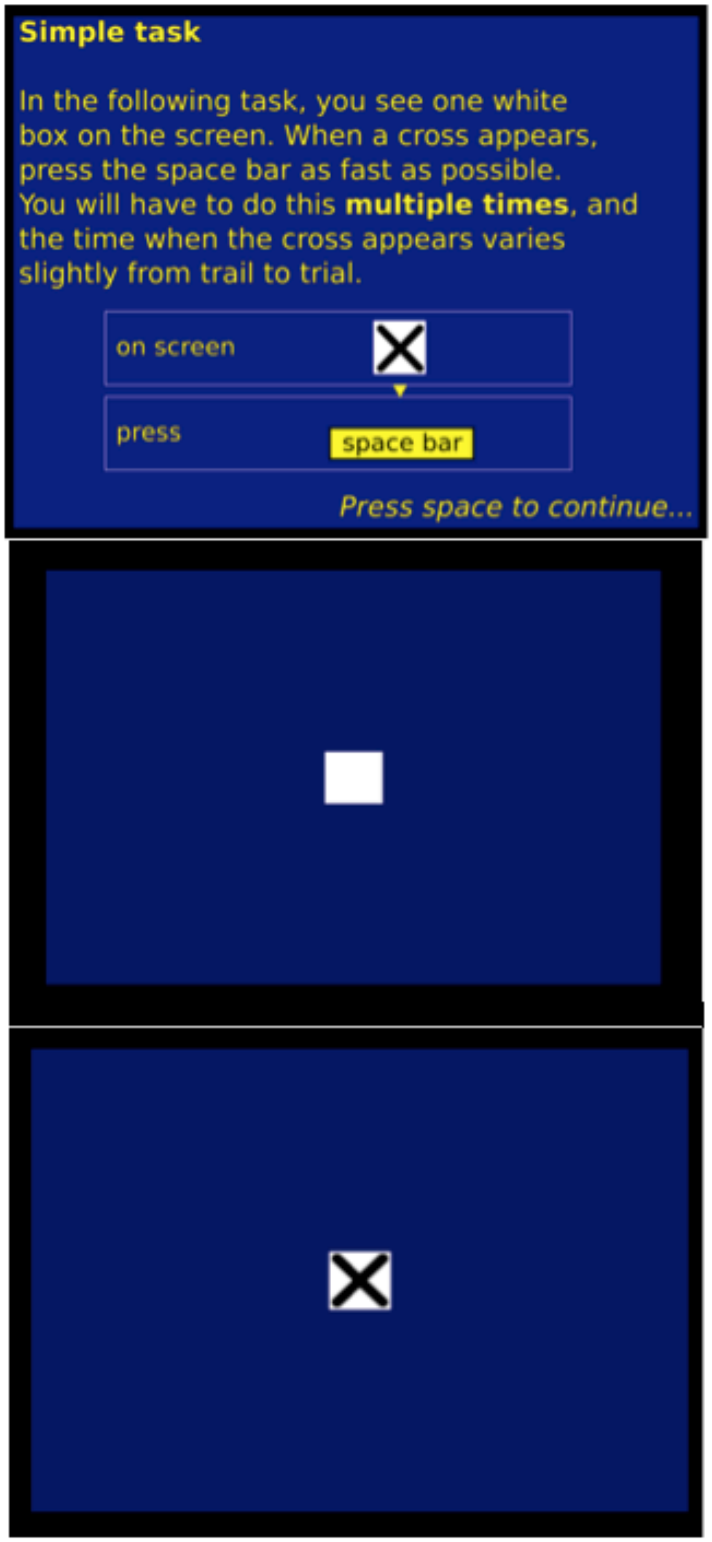
Study Start Information

Date participant signed consent ________________________________

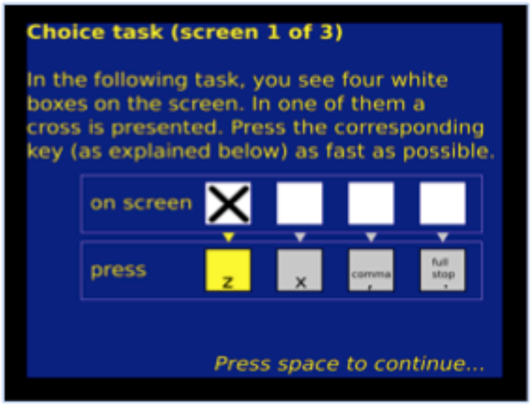
First session ________________________________

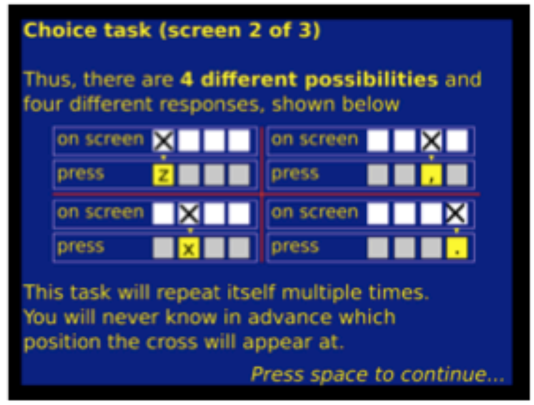
Final session ________________________________

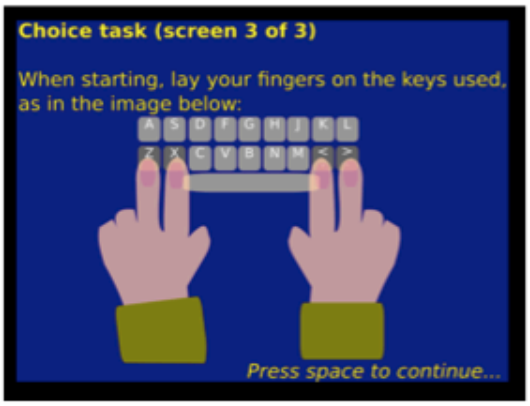
Reaction Time: Simple Task

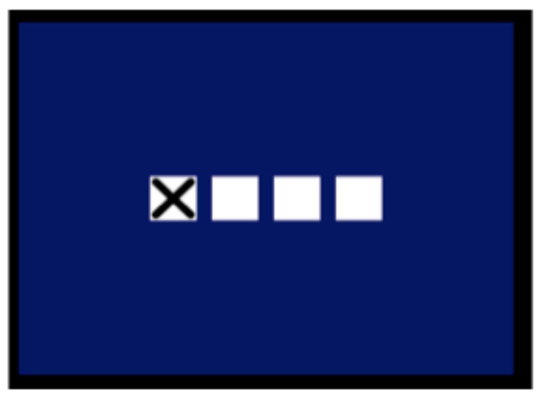


Reaction Time: Choice Task

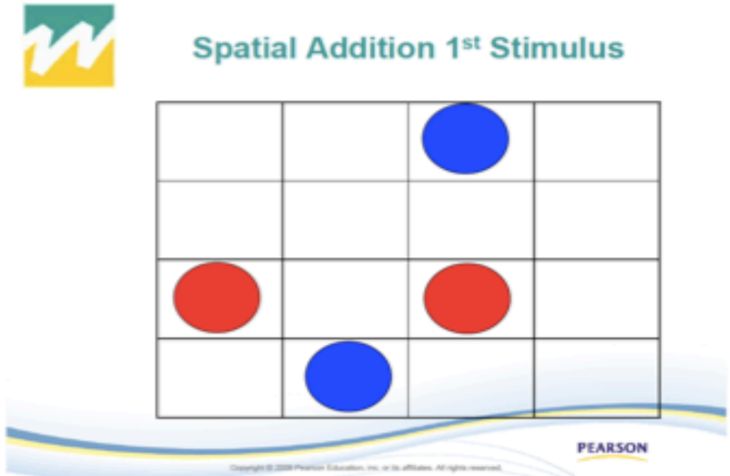


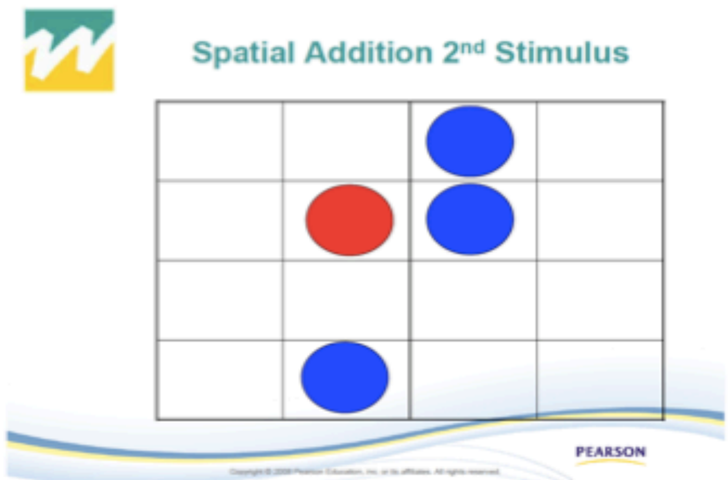


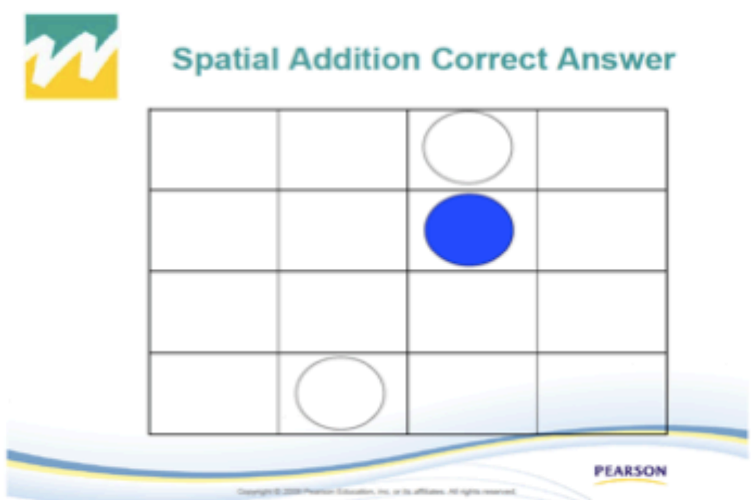




Spatial Addition Sample







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