Spring 2018

The Effects of Bingocize® on Cognitive Aging: A Health Promotion Intervention

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THE EFFECTS OF BINGOCIZE® ON COGNITIVE AGING: A HEALTH PROMOTION INTERVENTION

A Thesis
Presented to
The Faculty of the Department of Psychological Sciences
Western Kentucky University
Bowling Green, Kentucky

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Rilee Mathews
May 2018
THE EFFECTS OF BINGOCIZE® ON COGNITIVE AGING: A HEALTH PROMOTION INTERVENTION

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I dedicate this thesis to my parents, Orval and Julie Mathews, who have been a great source of inspiration and support through every path I have taken in life. I also dedicate this to my best friend, Joshua Meador, whose love and support has carried me through all of the best and most difficult times.
ACKNOWLEDGEMENTS

I would first like to thank my mentor, Dr. Matthew Shake for his support. Through his guidance, I have been able to grow and be motivated to continue to improve in my role as a researcher. I would also like to thank Dr. Jason Crandall for giving me the opportunity to work with the Bingocize® program. Being involved in the program has been a wonderful learning experience. Finally, I would like to thank Dr. Sharon Mutter for the encouragement and insightful comments for improving my thesis.
TABLE OF CONTENTS

Introduction ........................................................................................................... 1
Method .................................................................................................................. 10
Results ............................................................................................................... 19
Discussion ......................................................................................................... 23
References ......................................................................................................... 28
Appendix ............................................................................................................ 34
LIST OF FIGURES

Figure 1. Example of Flanker Task Stimuli ....................................................... 34
Figure 2. Example of Set Shifting Stimuli ......................................................... 34
Figure 3. Example of Dot-Counting Stimuli ....................................................... 34
Figure 4. Health Knowledge Question Display ................................................. 35
Figure 5. Exercise Display .................................................................................. 35
Figure 6. Coach’s Display Screen ...................................................................... 36
Figure 7. Scores on Dot Counting Pre and Post Intervention ............................ 36
Figure 8. Repeated Chair Stands Pre and Post Intervention ............................... 37
Figure 9. Arm Curls Pre and Post Intervention .................................................. 37
LIST OF TABLES

Table 1. Participant Demographics……………………………………………………38

Table 2. Mean Scores on Cognitive Tasks Pre/Post Intervention…………………………39

Table 3. Mean Scores on Measures of Functional Performance Pre/Post Intervention…40

Table 4. Mean Scores on Measures of Health Knowledge and Patient Activation Pre/Post
Intervention………………………………………………………………………………41
Previous research has suggested that physical exercise can play a role in not only improving functional performance, but also cognitive function. In this study, adults age 60 and older participated in a health promotion intervention that included two groups: (a) a Bingocize® group, who exercised and learned about relevant health information while playing bingo, and (b) a control group who only learned about relevant health information while playing bingo. The intervention was completed over the course of 10-weeks at community senior centers. Cognitive function, functional fitness, and health knowledge were assessed before and after the intervention to test for improvements. Through the course of the intervention, both the experimental and control groups showed improvements in several areas of cognition as well as functional performance. However, on a few tasks the experimental group showed improvement while the control group did not; specifically, on an updating (cognition) task, and two functional performance tasks (repeated chair stands and arm curls). Both of the groups also showed improvement in knowledge of relevant health information and a measure of patient activation (how confident a person feels in maintaining their personal health). From this, it is suggested that the Bingocize® program may be a promising approach to improving select aspects of cognition and functional performance in older adulthood.
Introduction

In America, the number of older adults age 65 and older will double over the next 25 years (Centers for Disease Control, 2013). This large increase in the number of older adults will bring forth the need for more research, careers, and resources specialized for their population. In particular, ameliorating age-associated declines in physical health and cognitive abilities, especially in sedentary older adults, has become a major focus. This is partly because those older adults who do not take care of their health typically require more medical attention, and have a higher likelihood of moving into an assisted living facility or a nursing home, both of which are predictive of shorter life expectancy (Fries, 2005). Thus, maintaining good health – both physical and cognitive – is a very important aspect of our daily lives, particularly for older adults who want to remain functionally independent and “age in place” (Scheidt & Schwarz, 2009).

A variety of normative age-graded changes occur in cognition and physical fitness during the lifespan. For example, widespread brain shrinkage occurs, which is especially observable in the caudate, cerebellum, and hippocampus (Raz et al., 2004). Older adults also show reduced functional connectivity between multiple brain regions (Grady, 2012). These types of neural changes in the aging brain are associated with the loss of executive (cognitive) functions, such as memory, attention, and processing speed. As for physical fitness, declines in functional performance, increased fall risk, and changes in body systems (i.e. circulatory, muscular, skeletal, etc.) can all occur with a high degree of variability between older adults. For example, organs become less efficient over time, which leads to the organs having to work harder. Older adults can also experience loss of muscle and bone mass (Siparsky, Kirkendall, & Garrett, 2014). These cognitive and
physical changes, in conjunction with the increasing older adult population, have increased the need for preventative and prescriptive approaches for older adults’ well-being.

One broad approach to maintaining or improving health for older adults is an intervention. Interventions have been used to implement a myriad of programs into the lives of older adults in an attempt to improve function in both physical and cognitive domains. For example, both physical and cognitive interventions have shown promising results in inducing neural change in older adults, such as an increase in gray matter and cortical thickening (for a review, see Bamidis et. al., 2014). As such, intervention approaches remain a popular research design in modern gerontology.

The present study specifically examined the cognitive benefits of Bingocize®, a health promotion program which combines exercise, health education, and Bingo with the goal of positively affecting older adults’ health and well-being. In particular, the study examined whether the intervention provides any benefit to executive functions (i.e., fluid cognitive abilities). Before describing the nature of the study, some background on physical and cognitive intervention research is needed. Although the current study is a health promotion intervention that includes physical activity, a summary of cognitive interventions is provided first, for the purposes of comparing the two approaches.

Cognitive Interventions

There are two basic categories of cognitive interventions: cognitive stimulation, which provides general cognitive stimulation and/or social skills, and cognitive training, which is used to train specific cognitive processes (Clare & Woods, 2004). The latter typically includes a standardized set of mental exercises that involve repeated practice
and increasing difficulty. In studies using older adult participants, finding positive results would suggest maintenance of plasticity into older adulthood. Some of the interventions used have been effective in improving various cognitive performance in older adults; however, in the majority of studies, the trained cognitive skill only transfers to similar tasks (i.e. “near transfer”), but not to different but cognitively similar tasks (i.e. “far transfer”). Furthermore, in some studies, the improvement in the specific skill is often only short term in duration (Ballesteros, Kraft, Santana, & Tziraki, 2015).

One prototypical example is a study comparing older and younger adults by Dahlin, Nyberg, Backman, and Neely (2008), who used a 5-week training program designed to help with updating information in working memory (WM) – a cognitive ability used to temporarily store and manage information. The working memory training involved updating single items in a list (i.e., numbers, letters, colors, and spatial locations). Participants were asked to hold the initial items in memory and update the contents of their memory with the most recently shown items (e.g., letters). Participants were asked to recall the last four of the single items in the correct order. After the training, both the younger and older adults showed improvements on the trained task. When they were assessed again 18 months later, they still showed improvement on the task compared to baseline. However, despite the improvement in the task, the older adults did not show transfer to other similar tasks that also required updating WM, whereas the younger adults showed limited transfer to an untrained updating task (3-back task). From these results, the researchers suggested that older adults may have a more limited neural plasticity than younger adults, casting doubt on the size of generalizability such training-based programs may have.
In another seminal intervention, the Advanced Cognitive Training for Independent and Vital Elderly (ACTIVE) study compared different approaches to cognitive training (Ball et. al., 2002). The study consisted of four cognitive intervention groups: memory training, reasoning training, speed of processing training, and a no-contact control group, with each of the training interventions lasting 5 to 6 weeks. Results showed that the older adults performed better on multiple measures of the specific cognitive ability they had been trained on in the intervention. However, a two-year follow-up did not demonstrate generalization to everyday performance (i.e. no far transfer). On the positive side, it is important to note that all the intervention groups showed less decline on self-reported Instrumental Activities of Daily Living (IADLs) five years after training, as compared to controls (Willis et al. 2006). So functionally speaking, some kind of intervention may provide a generalized benefit, but the precise mechanism of such a benefit is largely unclear because other potential confounds could be occurring over the years. A different approach that may be more promising is training with dual tasks, which a small number of studies have reported may transfer to performances in daily-life (Buitenweg, Murre, & Ridderinkhof, 2012). For example, a study by Hahn, Falkenstein, and Wild-Wall (2010) consisted of simultaneously performing a tracking task and a visual attention task within a task demanding driving simulation. After training both younger and older adults, the older adults showed differentially more improvement on the task in comparison to the younger adults. This suggests that older adults could possibly benefit more from training in complex environments.
Overall, the research on cognitive training interventions across the different training types (memory training, executive functions, etc.) have been inconsistent. Through cognitive training, older adults generally show improvements in the trained tasks, but have not consistently shown transfer to other cognitive tasks or abilities. In a thorough review of these kinds of “brain-training” programs, Simons et. al. (2016) concluded that these types of interventions improve performance on trained tasks, but found no convincing evidence that they improve performance on related, more generalizable tasks. Furthermore, they found very little convincing evidence that training can enhance performance on distantly related tasks or improve everyday cognitive performance. This demonstrates a need for further research in the area using more cognitive tasks, as well as testing after longer periods of time for transfer and maintenance of improvements. Despite the somewhat sobering literature on cognitive interventions, another line of intervention work has shown much more clear and consistent benefit to cognition: those that emphasize physical exercise.

**Physical Interventions**

While physical activity has obvious benefits to the body, it has also been shown in some cases to benefit certain cognitive abilities (Bamidis et. al., 2014). Interventions in this domain use a wide range of activities and exercises, which can depend on the participants included in the study. Many of these studies have shown improvements in cognitive function specifically through aerobic exercise. Aerobic exercise, also known as cardio, stimulates heart and breathing rates, which requires the heart to pump more oxygenated blood to the body. For example, a study by Voss et al. (2010) used fMRIs to examine the brain networks in older adults who participated in a one-year intervention
comparing the effects of aerobic and non-aerobic exercise. After the completion of the intervention, older adults in the aerobic exercise groups showed greater improvement than the non-aerobic group in functional connectivity efficiency within the Default Mode Network and Frontal Executive Network, which are areas associated with normative age-related brain dysfunction. This improvement also translated behaviorally with improvements on executive function tasks. In addition, the non-aerobic group also showed a smaller, but significant, increase in functional efficiency, suggesting that a wide variety of exercise can show improvements in cognitive function.

In another major study, Erickson et. al. (2011) conducted a one-year exercise intervention with older adults to evaluate whether hippocampal volume would increase along with a corresponding increase in spatial memory. To do this, participants were randomly assigned to one of two groups – an aerobic exercise group and a stretching control group. The aerobic group walked three days a week, while the control group did resistance training with bands, as well as yoga and stretching. It was found that the aerobic exercise group had an increase in volume of the left and right hippocampus, while the control group experienced age-related declines in volume. Behavioral assessment with a spatial memory task, however, showed that both groups improved in memory (the exercise group did not show differentially greater improvement). Interestingly, it was found that those older adults with higher fitness levels showed a greater improvement in memory performance. Chu, Chen, Hung, Wang, and Chang (2015), who examined two groups of older adults categorized as either high or low fitness, recently reported a similar finding. Using a within-subjects design, each of the participants were included in the experimental and control conditions, which included
completing a Stroop task after 30 minutes of exercise (experimental) and after reading a book about exercise (control). They found that repeated acute bouts of exercise led to general improvements in aspects of cognitive functions, specifically executive control and basic information processing, but again, those with higher fitness levels had greater benefits.

In a widely cited meta-analysis on the effects of physical fitness on cognitive function in older adults, Colcombe and Kramer (2003) reviewed a large number of exercise intervention studies. Physical training was found to have benefits for cognition, but they were selective. Particular processes in the brain (executive control) showed greater benefit than others. They also found that the magnitude of these effects on cognition varied by a great number of factors including length of the intervention, the type of intervention, and the duration of individual sessions. From this, it can be seen that further research is still needed to better understand the effects that physical interventions can have on cognitive functions. The many factors previously stated that have been found to change the outcomes of the interventions need to be further compared to understand the differential effects.

Unimodal versus Multimodal Intervention Approaches

While positive results have been seen in the aforementioned unimodal interventions (i.e. interventions tapping into a single domain), some researchers have argued that multimodal interventions – those that tap into multiple physical, cognitive and/or social domains – are the most effective for benefiting the cognition of older adults (Hertzog, Kramer, Wilson, & Lindenberger, 2008). Multimodal interventions have been used to target many domains, including lifestyle changes (both physical and mental),
social engagement, and cognitive stimulation; however, these multimodal interventions have in the past typically stimulated broad cognitive activity rather than specific cognitive functions.

Oswald, Gunzelmann, Rupprecht, and Hagen (2006) investigated the use of unimodal versus multimodal interventions and long-term effects of the interventions on daily activities in adults 75 or older. They used three unimodal groups (cognitive training, psychoeducational training and physical training), two multimodal groups (1) cognitive and physical training, and (2) psychoeducational and physical training), and a no treatment control group. The cognitive training consisted of fluid abilities, attention, and memory functions. The physical training consisted of balance, motor coordination and flexibility. Finally, the psychoeducational training aimed to strengthen coping mechanisms for daily life. After 30 training sessions for each group, the multimodal cognitive training and physical training showed the most improvement in cognitive performance compared to the control group. This enhancement was maintained over 5 years after training, and the participants showed an improvement in performing their instrumental daily activities (IADLs). This lasting improvement could be confounded by the participants maintaining an exercise routine over the 5 years; nevertheless, the results suggest there is differential cognitive benefit from a multimodal intervention.

In another study, Theill, Schumacher, Adelsberger, Martin, and Jäncke (2013) used three groups (simultaneous training, unimodal working memory training, or no training) to investigate the effects of simultaneously performed cognitive and physical training in older adults. The simultaneous training was a multimodal group that consisted of verbal working memory training and cardiovascular training, while the unimodal
working memory-training group was only trained cognitively. The results showed larger improvements in both training groups when compared to the participants who did not receive training, but the simultaneous training resulted in larger improvements compared to the unimodal training. This suggests that the simultaneous training of cognitive function and physical activity could potentially have greater benefits in older adults.

**Bingocize®**

One of the most significant challenges intervention researchers face is adherence. Older adult adherence to exercise programs is often low because they perceive exercise as a form of therapy (i.e., not recreational), and a negative, painful activity (Biedenweg et al., 2014). Furthermore, many exercise programs are solitary in nature, even though older adults are more likely to change health behaviors in group settings (Costello, Kafchinski, Vrazel, & Sullivan, 2011). Bingocize® was developed to overcome these barriers.

Previous research using Bingocize® has demonstrated that the program can be effective in improving functional performance. In a study by Crandall, Fairman, and Anderson (2015), older adults participated in Bingocize® that included Bingo and exercise using balance pads and exercise bands for 10-weeks. After the 10-weeks, significant improvements were found across all functional performance measures (i.e. Senior Fitness Test Battery); however, a control group was not included in the study for comparison. In another study by Crandall and Steenbergen (2015) similar methodology was used, but with the addition of a health education component. The health education was integrated into Bingo by adding health questions for the older adults to answer on some of the bingo rolls during the game, while the other bingo rolls required the older adults to do various exercises. After the program was completed, significant improvements were found in
functional performance in the exercise group compared to the control group, who did not participate in the exercises. However, no significant improvements were found in health knowledge. From these studies, it can be seen that Bingocize® can potentially be beneficial for older adults’ functional performance, but benefits to health education and cognitive function remain unclear.

**The Current Study**

In the current study, the effects of a multimodal intervention including physical activity, health education, and social engagement in the context of Bingo (i.e., Bingocize®) were examined with older adults to assess potential improvements in cognitive function. Two groups were included in the intervention for comparison across conditions: an experimental group that completed physical exercise and health education within a twice-weekly (10-week) Bingo game using the Bingocize® app, and a control group that participated in twice-weekly (10-week) health education and Bingo only, also using the Bingocize® app. We hypothesized that the participants in the experimental group would show better performance in aspects of executive function, such as updating, inhibition, shifting, and fluency.

**Method**

**Participants**

We recruited 147 community-dwelling adults ages 60 and over from counties in the western Kentucky and Tennessee region (e.g. Warren & Daviess counties in KY, and Davidson County in TN) by going to senior facilities to present the potential benefits of the study to the older adults and facility directors. Of those older adults, 117 consented to
participate, and 84 completed the study. Participants had to meet the following criteria to be included in the study: (1) no history of neurological impairment, (2) are not at high risk for falling (as determined by a health screening survey), (3) no colorblindness, (4) normal or corrected-normal vision, (5) some mobility (i.e., not wheelchair-bound), and (6) no signs of dementia (as assessed by a modified version of the Telephone Mini-Mental Status Exam; TMMSE) (Newkirk et al., 2004). Participants were also required to have a physician's release to be included in the study. After consenting to participate and being screened for fall risk, the participants were administered the TMMSE. The TMMSE is administered over the phone; participants were required to score at least 17 out of 21 to be included in the study.

Table 1 shows the demographics of the participants who completed the study. The mean age of the participants was 73.48 years (SD = 7.97), with 85% being female, and 73% Caucasian. Overall, the control and experimental groups were homogenous in demographics. However, we did find that the control group had a higher rate of diabetes among participants than the experimental group.

Materials

Cognitive battery. We used a subset of executive function cognitive tasks taken from the Executive Abilities: Measures and Instruments for Neurobehavioral Evaluation and Research (Kramer et. al., 2014). The EXAMINER battery has been used and normalized with a wide variety of populations and age groups, and many tasks in the battery are based on the theoretical framework of executive function proposed by Miyake and colleagues (Miyake & Friedman, 2012). For the present study, we assessed
participants on four aspects of fluid cognitive function: fluency, updating, inhibition, and shifting. Descriptions of the tasks used to measure these functions are below.

**Fluency.** Participants completed two fluency tasks. The first was a phonemic fluency task. Participants were asked to name as many words as possible that begin with a particular letter. Time was limited to 60 seconds, and they could not use names of people, places, numbers or grammatical variants (i.e. bake, bakes, baked). The second was a category fluency task, where participants were asked to name as many items as possible that belong to a particular category in 60 seconds. Scores were based on the number of correctly used words listed.

**Inhibition.** Participants completed two tasks that assessed inhibitory ability – a flanker task and an anti-saccade task. In the flanker task, participants were asked to focus on a small cross at the center of the computer screen. The cross was displayed for 1000 – 3000 ms and then followed by a row of five arrows presented in the center of the screen either above or below the fixation cross (see Figure 1). The stimuli were shown on each trial for a total of 1000 ms. Participants were asked to indicate whether the center arrow was pointing to the left or right using the left and right arrow keys on the keyboard. Half of the trials were congruent in that the all of the arrows point the same direction. The other half of the trials were incongruent and not all of the arrows pointed in a single direction. They were first presented with 8 practice trials. To continue to the task, participants were required to pass the practice trials with 75% accuracy. If this was not achieved after three sets of practice trials, the participant did not advance to the test trials. If the participant passed, then they continued for 48 test trials. The final flanker score was calculated using reaction time and accuracy. Both of these measures ranged from a score
of 0-5. The accuracy score was the proportion of correct responses multiplied by 5 (i.e. 80% correct would equal a score of 4). To calculate reaction time score, a log (Base 10) transform was applied to the median RT score. A minimum reaction time was set to 500 ms and a maximum at 3,000 ms. Scores outside of this range were truncated. The total Flanker score is the sum of the accuracy and reaction time scores, so total scores range from 0-10 (Kramer et. al., 2014).

On the anti-saccades task, the participant’s primary task was to move their eyes in the opposite direction of a moving stimulus. The experimenter watched the participants’ eye movements and recorded whether the participant’s initial eye movements were in the correct direction. The task consisted of three blocks of trials. On each screen, a fixation point was displayed in the center. Participants were asked to move their eyes based on the presentation of the stimulus – a white dot. On each of the trials, the dot would initially appear in the center of the screen and then move to either the left or right side of the screen. In the first block (pro-saccade trials), the participants were asked to move their eyes in the direction of the dot for a total of 10 trials. In the critical second and third trials (anti-saccade trials), the participants were asked to move their eyes in the opposite direction of the dot. There were 40 anti-saccade trials in two separate blocks. The final score was based on the average score of the two blocks.

**Shifting.** Participants completed one task to assess shifting. In this set shifting task, participants were asked to match a stimulus on the top of the screen to one of two stimuli in the lower corners of the screen. They matched objects by either color or shape. There were two types of trials in the task – shift and non-shift. In the shift trials, participants were required to shift their goal from the previous screen. In the non-shift
trials, subsequent trials had the same goals. When presented with the task, each screen contained a red triangle in the bottom left corner and a blue rectangle in the bottom right corner (see Figure 2). At the start of each trial, a cue on how to match the objects appeared at the bottom of the screen. The cue was the word “shape” or “color.” This was followed by a blue triangle or red rectangle stimulus in the top center of the screen. Participants were asked to respond based on the given cue. To respond, the participants used the left and right arrow keys on the keyboard. The left arrow key corresponded with the color red and triangle, while the right arrow key corresponded with the color blue and rectangle. Participants were given a practice set with 16 trials and were required to have 75% accuracy to pass to the test trials. If 75% accuracy was not achieved, the participants did not advance to the test trials. After the practice, the task continued for 64 trials. The final score was calculated based on reaction time and accuracy. The accuracy score was the proportion of correct responses in the shifting block multiplied by 5, creating a range from 0 to 5. For scoring of reaction time, a log (Base 10) transform is applied to the median RT score. To reduce skewing, the minimum RT was set to 400 ms and maximum reaction time to 2800 ms with scores falling outside that range being truncated. The total set shifting score is the sum of the accuracy and reaction time scores, creating a range from 0-10 for total score (Kramer et. al., 2014).

**Updating.** In the dot counting task, the participants looked at a screen with a mixed array of green circles, blue circles, and blue squares. They were asked to count all of the blue circles on the screen, one at a time, out loud and to remember the final total. Once they finished counting on one screen, the next screen was displayed with a different mix of the same stimuli. Participants repeated the same procedure on each of the
following screens until a screen with question marks was displayed (see Figure 3). This prompted the participants to recall the total amount of blue circles from each individual screen in the order they were presented. The participants were first given 3 practice trials with 1, 2, and 3 displays to count and recall. After the practice, the number of displays began with two and increased by one display at a time to seven, resulting in a total of 6 test trials. Performance on this task was scored two ways – lenient and strict. The lenient method gave credit for the correct numbers being recalled in any order, while the strict method gave credit only for the numbers recalled in the correct order. The total scores could range from 0 to 27.

**Physical assessment.** Each of the participants were assessed on basic physical criteria and health state, including blood pressure, height, and weight. Participants were given the Short Physical Performance Battery (SPPB) to access their physical abilities, functional fitness, and lower body muscular strength (Vasunilashorn et. al., 2009). To begin, the participants were given a short series of balance tests. In the first test, the participants were asked to stand with their feet together for 10 seconds. This was followed by a semi-tandem (standing with the side of the heel of one foot touching the big toe of the other foot) and a tandem (standing with the heel of one foot in front of and touching the toes of the other foot) balance assessment. The next test assessed was gait speed. This was used to observe how the participants normally walk by timing their walk on a short course. Finally, the participants completed a two-part chair stand test. They first completed a single chair stand where they were allowed to use their arms if needed. Then they completed repeated chair stands - standing and sitting five times - where they were not allowed to use their arms with a one-minute time limit. Scores on the SPPB
could range from 0 to 12, with the first two balance tests being 1 point each, the second balance test 2 points, the gait speed test being 4 points, and the chair stand also 4 points. Participants were also given an arm curl test to see how many they could complete in order to assess upper body muscular strength.

**Health knowledge and activation tests.** After the physical assessments, the participants were given a health knowledge test to complete. This consisted of 30 multiple-choice questions about fall risk and osteoarthritis which were created using information from the Centers for Disease Control (CDC) websites on those topics (e.g. *What are the three best types of exercises to do if you have osteoarthritis?*). They were also given the Patient Activation Measure (PAM; Hibbard, Stockard, Mahoney & Tusler, 2004). This measure asked participants to rate their agreement with statements regarding how confident they are with maintaining their health and how knowledgeable they feel about their health (e.g. *I know what each of my prescribed medications do*). The score on the PAM could range from 0 to 100, and the levels PAM levels ranged from 1 to 4.

**Design and Procedure**

The research study was designed as a pre-test/post-test intervention with random assignment to one of two conditions: (a) a “Bingocize®” group who completed exercises and health education in the context of Bingo, or (b) a “Control” group who completed only health education in the context of Bingo. The participants were randomized in clusters; a faculty member outside of the study randomly assigned the participant groups in each facility to one of the two conditions. This random assignment was not done until after the pre-testing was completed, so those collecting the data were blind to the group
assignment. Researchers who were blind to group assignment also completed post-testing.

Participants were required to complete a questionnaire that contained information about their current health state and health issues. After the initial consent form, a questionnaire to assess their health (for eligibility purposes), and a physician’s release was acquired, pretesting began at a central facility located at each senior community center. For the cognitive tasks, participants were given the EXAMINER battery tasks in the following order: fluency tasks, flanker, set shifting, dot counting, and finally the anti-saccade. Participants also completed the physical assessment (SPPB), arm curl test, health knowledge test and the PAM. Finally, their height, weight, and blood pressure was collected. Once all of the participants at the facility completed the pretesting, the 10-week intervention began with each of the groups meeting twice per week for approximately one hour each session (i.e., ~20 hours of activity). During the intervention, both of the groups played virtual bingo on tablets using the Bingocize® app. Below, we describe a typical game session.

**Gameplay design.** On the app, the participants viewed a screen with a modified bingo card consisting of a randomly generated set of numbers. On each turn, a virtual wheel appeared on the screen and spun to a particular number. For the Bingocize® group, after each spin of bingo, either a health knowledge question (see Figure 4) or an exercise (see Figure 5) appeared on the screen. The coach also had a tablet with a different display (see Figure 6). Their screen displayed the wheel along with the exercises, health knowledge questions, or any notes that were beneficial to the session. For the questions, participants were required to answer the questions correctly before they could mark the
corresponding number on their card and be ready for the next spin. Participants were forced to continue choosing until they identified the correct answer, ensuring everyone chose the correct information. For the control group, each spin resulted only in a health knowledge question to answer or no activity (i.e. just mark the number on the card). The Bingocize® group’s exercises focused on improving cardiovascular fitness, muscular strength and endurance, flexibility, and balance. Each session included around 12-15 different exercises, slowly increasing the repetitions for exercises after each session. A coach, who was a trained staff member at the facilities and compensated $400, led the sessions. The coach called out the exercises and demonstrated them to the participants. They also read the health knowledge questions aloud and kept track of the participants’ activity, making sure everyone followed along. Each time a participant got a bingo, they received a prize. Prizes included various household items such as toilet paper, paper towels, and tissues. Participants were asked to attend at least 80% of the sessions in order to complete the study.

After 10 weeks, participants who were still in the study completed post-testing. The process for post-testing was the same as pretesting; however, participants were given a different form of the EXAMINER battery with slightly altered tasks in order to control for practice effects. For example, the two fluency tasks changed which letter and category were chosen, and the dot-counting task and the anti-saccade task changed in presentation (i.e. the number of dots vary on the displays and the correct eye movements were not in the same order as the pretest). Participants also completed the same physical assessments, PAM, and health knowledge questions. After the post-testing, each of the participants received $40 for participating in the study. Additionally, for every Bingocize® session the
participants attended, their name was entered into a drawing for $100, which was done after post-testing at each of the individual groups at the facilities.

**Results**

After the 10-week intervention, we found improvements in some (but not all) aspects of cognition, functional performance, and health knowledge. The findings from each individual task are described below. Mean scores for the experimental and control groups from pre to post intervention on the cognitive, functional performance, health knowledge and patient activation (PAM) measures can be seen in Tables 2 thru 4, respectively. Data were analyzed with a series of 2 (Time; within-subjects) x 2 (Group; between-subjects) mixed factorial ANOVAs, unless otherwise noted.

**Fluid Cognition**

For the phonemic fluency task, there was no main effect of Time, $F(1,81) = 1.01$, $p = 0.32$, *ns*. There was also no main effect of Group, $F(1,81) = 0.03$, $p = 0.87$, *ns*. Finally, there was no Time x Group interaction, $F(1,81) = 1.58$, $p = 0.21$, *ns*.

For the categorical fluency task, there was a main effect of Time, showing that both groups decreased in performance on categorical fluency from pre- to post-intervention, $F(1,81) = 61.18$, $p < 0.01$, $\eta^2_p = 0.43$. There was no main effect of Group, $F(1,81) = 0.05$, $p = 0.82$, *ns*. There was also no Time x Group interaction, $F(1,81) = 0.01$, $p = 0.93$, *ns*.

For the flanker task, there was a main effect of Time, showing that both groups improved in inhibition from pre- to post-intervention, $F(1,76) = 4.32$, $p < 0.05$, $\eta^2_p = 0.05$. There was no main effect of Group, $F(1,76) = 2.17$, $p = 0.15$, *ns*. There was also no Time x Group interaction, $F(1,76) = 0.15$, $p = 0.69$, *ns*. 
For the anti-saccades task, there was a main effect of Time, showing that both groups improved in inhibition from pre- to post-intervention, $F(1,75) = 13.35, p < 0.001, \eta_p^2 = 0.15$. There was no main effect of Group, $F(1,75) = 1.44, p = 0.23, \text{ns}$. There was also no Time x Group interaction, $F(1,75) = 0.79, p = 0.38, \text{ns}$.

For the shifting task, there was a main effect of Time, showing that both groups improved in shifting over the course of the intervention, $F(1,78) = 6.98, p < 0.05, \eta_p^2 = 0.08$. There was no main effect of Group, $F(1,78) = 1.33, p = 0.25, \text{ns}$. There was also no Time x Group interaction, $F(1,78) = 1.03, p = 0.31, \text{ns}$.

For the dot counting task, there was no main effect of Time, $F(1,79) = 1.09, p = 0.30, \text{ns}$. However, there was a main effect of Group that showed that the experimental group was slightly better in updating ability than the control group, $F(1,79) = 4.10, p < 0.05, \eta_p^2 = 0.05$. An interaction of Time x Group showed that the experimental group improved over the intervention, while the control group did not, $F(1,79) = 5.75, p < 0.05, \eta_p^2 = 0.07$ (see Figure 7). This was confirmed by pairwise t-test comparisons for the Experimental group, $t(44) = -2.80, p = 0.008$ and Control group, $t(35) = 0.83, p = 0.41$, respectively.

**Synopsis.** Given the results of the cognitive battery, the most interesting finding is the differential improvement on the updating task. Although the experimental group improved slightly in their updating ability compared to the control group, the control group did not show any change from pre- to post-intervention. As for the other tasks, both groups showed improvements from pre- to post-intervention on all except the fluency tasks. Because both groups showed those improvements, they are most likely due to practice effects.
**Functional Performance**

For the total SPPB score, there was a main effect of Time, showing that both groups improved their score from pre- to post-intervention, $F(1,83) = 13.86, p < 0.001$, $\eta^2_p = 0.14$. There was no main effect of Group, $F(1,83) = 1.44, p = 0.23, \text{ns.}$ There was also no Time x Group interaction, $F(1,83) = 0.003, p = 0.96, \text{ns.}$

For the first balance test (feet together), there was no main effect of Time, $F(1,83) = 0.26, p = 0.61, \text{ns.}$ There was also no main effect of Group, $F(1,83) = 2.53, p = 0.12, \text{ns.}$ Finally, there was no Time x Group interaction, $F(1,83) = 0.26, p = 0.61, \text{ns.}$

For the second balance test (semi-tandem), there was no main effect of Time, $F(1,83) = 0.17, p = 0.68, \text{ns.}$ There was also no main effect of Group, $F(1,83) = 2.89, p = 0.09, \text{ns.}$ Finally, there was no Time x Group interaction, $F(1,83) = 0.17, p = 0.68, \text{ns.}$

For the third balance test (tandem), there was no main effect of Time, $F(1,83) = 3.62, p = 0.06, \text{ns.}$ There was also no main effect of Group, $F(1,83) = 0.89, p = 0.35, \text{ns.}$ Finally, there was no Time x Group interaction, $F(1,83) = 3.62, p = 0.06, \text{ns.}$

For the gait speed test, there was a main effect of Time, showing that both groups improved their gait speed from pre- to post-intervention, $F(1,83) = 8.71, p < 0.01, \eta^2_p = 0.10$. There was no main effect of Group, $F(1,83) = 1.01, p = 0.32, \text{ns.}$ There was also no Time x Group interaction, $F(1,83) = 0.08, p = 0.77, \text{ns.}$

For the chair stand, there was a main effect of Time, showing that both groups improved the amount of chair stands completed from pre- to post-intervention, $F(1,80) = 13.38, p < 0.001, \eta^2_p = 0.14$. There was no main effect of Group, $F(1,80) = 0.25, p = 0.62, \text{ns.}$ An interaction of Time x Group showed that the experimental group improved over the intervention, while the control group did not, $F(1,80) = 4.44, p < 0.05, \eta^2_p = 0.05$.
0.05 (see Figure 8). This was confirmed by pairwise t-test comparisons for the Experimental group, $t(45) = 3.93, p < 0.001$ and Control group, $t(37) = 1.23, p = 0.23$, respectively.

For the arm curls, there was a main effect of Time, showing that both groups improved in the amount of arm curls completed from pre- to post-intervention, $F(1,81) = 11.4, p = 0.001, \eta^2_p = 0.12$. There was no main effect of Group, $F(1,81) = 1.93, p = 0.17$, ns. An interaction of Time x Group showed that the experimental group improved over the intervention, while the control group did not, $F(1,81) = 4.78, p < 0.05, \eta^2_p = 0.06$ (see Figure 9). This was confirmed by pairwise t-test comparisons for the Experimental group, $t(45) = -3.84, p < 0.001$ and Control group, $t(37) = -0.79, p = 0.43$, respectively.

Synopsis. With the results from the functional performance tasks, it is evident that the intervention was more beneficial for some areas than for others. More specifically, both groups showed improvements in the arm curls and repeated chair stands, with the experimental group showing greater improvement in each. As for the other areas that showed improvements in both groups, the SPPB and gait speed, there could be extraneous factors that led to these improvements. For example, the control group could have been exercising outside of the intervention, thus increasing their functional performance on their own.

Health Knowledge and Activation

For the health knowledge test, there was a main effect of Time, showing that both groups improved their health knowledge from pre- to post-intervention, $F(1,83) = 275.56, p < 0.001, \eta^2_p = 0.77$. There was no main effect of Group, $F(1,83) = 0.58, p = 0.45$, ns. There was also no Time x Group interaction, $F(1,83) = 0.42, p = 0.52$, ns.
For the PAM score, there was a main effect of Time, showing that both groups improved their health activation from pre- to post-intervention, $F(1,82) = 8.30, p < 0.01, \eta^2_p = 0.09$. There was no main effect of Group, $F(1,82) = 0.19, p = 0.67, ns$. There was also no Time x Group interaction, $F(1,82) = 0.002, p = 0.96, ns$.

For the PAM level, there was a main effect of Time, showing that both groups improved their level from pre- to post-intervention, $F(1,82) = 12.39, p = 0.001, \eta^2_p = 0.13$. There was no main effect of Group, $F(1,82) = 0.003, p = 0.96, ns$. There was also no Time x Group interaction, $F(1,82) = 0.02, p = 0.89, ns$.

**Synopsis.** On all of the health knowledge aspects of the intervention, both groups showed improvement. The improvement on the health knowledge test can be easily explained in that both groups were receiving health education over the course of the intervention. As for the scores on the PAM, learning more about health through the intervention could have led to the group-equivalent improvements.

**Discussion**

The current study explored the potential benefits to cognitive and physical function in older adults with the administration of a health promotion intervention. Although we did not find significant improvements for the experimental group over the control group in all areas, the findings are an important step in designing engaging and adherence-promoting intervention programs that can benefit the overall health and well-being of older adults. Within the cognitive battery, the experimental group only showed differential improvement over the control group on the updating task, although it is noteworthy that this was the most difficult cognitive task in the battery.
In terms of functional performance, both groups showed improvements in arm curls as well as chair stands, but the experimental group improved significantly more. These improvements are beneficial because both the arm curl test and the chair stand test have been found to be related to fall risk (Zhao & Chung, 2016). Finally, significant increases in the PAM score were found in both groups, which is an important finding because the PAM has been found to reliably predict future ER visits, hospital admissions and readmissions, medication adherence and more (Hibbard & Greene, 2013). This is especially important for older adults due to their heightened fall risk and issues with health adherence, whether that be issues with prescription adherence or maintaining their health in general. The higher scores on the PAM suggest that overall, participants became more confident and knowledgeable about maintaining their health after the completion of the intervention.

**Limitations**

In the current study, we found improvements across both groups on some of the outcome measures, regardless of whether they received the exercise portion of the intervention. A few limitations may contribute to this finding. First, both groups received health education over the course of the intervention. From this, it is a possibility that the control group was encouraged to become involved in exercise outside of the intervention due to the health information they were learning. The participants could have also had encouragement from other sources. When recruiting the participants at the facilities, they were made aware that they could be randomly assigned to one of the two conditions – exercise or no exercise. Many participants wanted to be in the experimental group to complete the exercises, which could have in turn caused the control groups to pick up
some type of exercise routine on their own. We did not collect data on participants’
changes in private exercise routines during the program, so we cannot eliminate that
possibility.

In addition, there were other factors that we did not collect data on during the
intervention that could have contributed to our findings. First, we did not measure level
of exertion during the exercises. Without this measure, we cannot be sure that all of the
participants were putting forth enough effort with the exercises. It is possible that with
more exertion and intensity in the exercises, there could have been more improvements in
aspects of both cognition and functional performance for the experimental group.
Another factor we did not take into account was diet. In previous research, it has been
found that diet can have an effect on cognition. For example, in a study by Scarmeas and
Stern (2009), the Mediterranean diet was studied in relation to mild cognitive impairment
(MCI), which is the term given for older adults who are in the transitional period between
normal aging and dementia or Alzheimer’s disease. The results of the study suggested
that a higher adherence to the diet is associated with a trend of reduced risk of MCI. In
relation to the current study, a healthier diet, such as the previously mentioned
Mediterranean diet, could moderate any cognitive improvements older adults showed as a
result of the exercise.

As seen in Table 1, the participants in our study differ from participants that have
been previously seen in research studies on exercise interventions; the older adults in our
study, overall, were less educated with poorer health. As previously mentioned, Chu et al.
(2015) found that as a result of their exercise intervention, those who were characterized
as having higher fitness levels at the start of the intervention had greater benefits. This
suggests that with a healthier sample of older adults, there could have possibly been more improvement. Because of this, more research is needed to provide a better understanding of how to further benefit those with lower levels of health rather than only those who are already relatively healthy.

Future Directions

Due to the limitations of the current research design, further research is needed to better understand the role each aspect of the program can play in engendering improvements in cognitive function and health education. To do this, future studies implementing the Bingocize® program could add an additional set of control groups – for example, bingo-only and/or a no-contact control groups. For the bingo only group, the health education component could be taken out of the game so they are only playing virtual bingo over the course of the intervention. For the no contact control, the participants would not be involved in the intervention at all; they would only complete the pretesting and then post testing after the length of the intervention. With these additional control groups, we would be able to compare the effects of the health education as well as some of the effects of social engagement. Separating all of these aspects of Bingocize® would benefit our understanding on how each component plays a role in improving cognitive function, health education, confidence in health, and physical fitness.

As mentioned in the limitations, diet could also be an important factor in understanding benefits to cognition. Future studies using the Bingocize® program could track participants’ diet habits by having them keep a journal of what they eat each day. With this, we might be able to have a clearer insight on whether their diet is having an
effect on improvements over the course of the intervention. Future studies could also encourage a change in diet, along with keeping a journal of their meals. Then, different diets could be examined to see if the diet change helps to further improvement from the intervention.

Another benefit to future studies would be to make changes to the intervention itself. This could include the length of the intervention, the intensity of the sessions, the types of training, and the length of individual sessions. As previously mentioned, research has suggested that there are certain optimal conditions for an intervention to improve aspects of cognition (Colcombe & Kramer, 2003). It would also be very beneficial to examine some other types of cognitive tasks, perhaps ones that require the simultaneous usage of multiple aspects of fluid cognition, which would more closely approximate common real-world situations that older adults experience.
References


Erickson, K., Voss, M., Prakash, R., Basak, C., Szabo, A., Chaddock, L., Kim, J., Heo, S., Alves, H., White, S., Wojcicki, T., Mailey, E., Vieira, V., Martin, S., Pence,


APPENDIX

Figure 1. Example of Flanker Task Stimuli

Figure 2. Example of Set Shifting Stimuli

Figure 3. Example of Dot-Counting Stimuli
**Figure 4. Health Knowledge Question Display**

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<td>6</td>
<td>19</td>
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13. It is not possible to have more than one form of arthritis at a time.

- True
- False

**Figure 5. Exercise Display**

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18. Lateral Raises: Place resistance band beneath both feet. With hands gripping handles, slowly raise arms in front until parallel with the floor. Hold a few seconds and slowly return-
Figure 6. Coach’s Display Screen

Figure 7. Scores on Dot Counting Pre and Post Intervention
Figure 8. Repeated Chair Stands Pre and Post Intervention

Figure 9. Arm Curls Pre and Post Intervention
Table 1  
*Participant Demographics*

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Numbers in parantheses () are standard deviations; in brackets [] are percentages  
*BMI*, Body Mass Index; *MMSE*, Mini-Mental State Examination
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*Note.* The range of scores on each measure is listed in the Materials section.
† Main effect of Time, * Main effect of Group, ‡ Time x Group Interaction
Table 3
Mean Scores (and Standard Error) on Measures of Functional Performance Pre and Post Intervention

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<td>Repeated Chair Stands‡</td>
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<td>Arm Curls‡</td>
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Note. The range of scores on each measure is listed in the Materials section.
† Main effect of Time, * Main effect of Group, ‡ Time x Group Interaction
Table 4

*Mean Scores (and Standard Error) on Measures of Health Knowledge and Patient Activation Pre and Post Intervention*

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<tr>
<td>PAM Level†</td>
<td>2.94 (0.12)</td>
<td>3.21 (0.09)</td>
</tr>
</tbody>
</table>

*Note.* The range of scores on each measure is listed in the Materials section.

† Main effect of Time, * Main effect of Group, ‡ Time x Group Interaction
Curriculum Vitae

Education:
Western Kentucky University, Bowling Green, KY
M.S. Psychological Science
Concentration: Biobehavioral Psychology
Fall 2016 – Spring 2018

Western Kentucky University, Bowling Green, KY
B.S. Psychological Sciences
Concentration: Biobehavioral Psychology
Minor: Gerontology
Summa Cum Laude
Fall 2013 – Spring 2017

Relevant Experience:
Research Assistant, Fall 2015-Present
Western Kentucky University
The Adult Learning Lab
Duties: Lead participants through experimental procedures and administer cognitive tasks

Service Learning Project, Spring 2017
Barren River Adult Day Care Center
Bingocize Program
Duties: Instruct adults through the Bingocize Program, assisting in various exercises and communication skills

Research Assistant, Fall 2014- Spring 2015
Western Kentucky University
Cognitive and Behavioral Neuroscience Lab
Duties: Led participants through experimental procedures, applied EEG netting, and observed data while participants completed tasks to monitor for errors

Service Learning Project, Fall 2015
Chandler Park Memory Care, Assisted Living Facility
Bingocize Program
Duties: Instructed older adults through the Bingocize Program, assisting in various exercises

Research Skills:
Experimental design, data collection and analysis
Field research and health intervention protocols
Eye Tracking
SPSS
EEG net application
Awards and Honors:
Regents Scholarship Recipient – Covers in-state tuition
Faculty-Undergraduate Student Engagement (FUSE) Grant Recipient ($4,000)
Kentucky NSF EPSCoR Research Scholars Program Recipient ($7,439)
Nominated for Outstanding Junior Award, WKU Dept. of Psychological Sciences, 2016
Outstanding Senior Award, WKU Dept. of Psychological Sciences, 2017

Conference Presentations:


Mathews, R., Shake, M.C., & Massy, E. (2017). The role of age, interest, and cognition on mind wandering during reading. Poster Accepted for Presentation at the IAGG World Congress of Gerontology and Geriatrics. San Francisco, CA.


Manuscripts Under Review: