A Study on the Perception of Brain Games and their Effect on Memory and Cognitive Skills

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A STUDY ON THE PERCEPTION OF BRAIN GAMES AND THEIR EFFECT ON MEMORY AND COGNITIVE SKILLS

by

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ABSTRACT

In this thesis, a literature review was conducted in order to analyze the numerous sources that investigated the effects memory games may have on participants. Each study covered different scopes and methods in the field of cognitive improvement, which gave way to a variety of results used to create a comprehensive literature review. The experiments included in the literature review gathered evidence to find the effect that "brain" games had on memory and cognitive skills. An explanation and analysis were made on the brain's deterioration as it ages and the varying amounts of plasticity it contains. The overall perspective gained from the literature review allowed for a better understanding of the results of the surveys conducted for this thesis. The distinctive ways to encourage and improve brain health were researched, and a particular focus was placed on memory games regarding brain health factors. Overall, the benefits identified covered an increase in working memory, skills, and processing speed. However, there was an indication that the improvements were only for the tasks at hand. When research was conducted on transferable activities, there was little to no proof of the transferability of measured improvements. During the research portion of the thesis, a survey was conducted that involved 90 participants from the age of 60 and older on their perception of brain games. The results of the 9-question survey showed statistically significant correlations between the amount of times individuals had played memory games and their perception of both the simplicity and effectiveness of these games. Participants who had played games more frequently viewed the games as both more effective and simpler. Similarly, participants with more education perceived the games as being simpler. The male participants in this study were found to play memory games more frequently than the women. Overall, the correlations drawn

from the results of the survey promote the enriched discussion on the subject of memory games and cognitive improvement.

DEDICATION

For my family,

you give me strength

and courage beyond all measures.

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INTRODUCTION

In today's society, there is a growing market for products that promise to combat aging, keeping both the mind and body youthful. Within this market, an onslaught of products focusing on cognitive rejuvenation and improvement have emerged, many of which are online products that claim to enhance brain health through scientifically proven processes. Assessing the validity of these claims is an important but complicated process for the consumer, but being aware of the facts is a literal game changer. Due to increased demand for products that offer cognitive improvement there is a growing necessity to assess the effectiveness of these games. A recognizable correlation exists between the growing number of computer based memory games and the increasing number of people that play them. Our generation has developed into a technologically dependent society. People turn to electronics in order to get information as well as recently, to play games that claim to improve brain health. Understanding both the perception potential users may have of these products and the evidence provided by recent studies will allow for a holistic analysis of the effectiveness of these brain games. Baby boomers and senior citizens have had to adjust to a world that is drastically different from the one that they grew up in. The perception that these groups have about the technological method of brain health is extremely significant, especially since the older one becomes, the more essential it is to take care of the aging brain. In the next 20 years, older adults will account for about 25% of the United States population (U.S. Census Bureau, 2011). The cognitive care and capabilities of this age group is important when considering how large of a percentage this population group will be in the near future. Cost effective protective procedures will be an effective method for ensuring quality of life and independence.

The workings of the human brain have always been shrouded in mystery, but as technology progresses, the capacity of knowledge accumulated also improves. Fascinations with aging have spurred extensive research into the cognitive aging process. These studies have demonstrated the effects aging has on the human brain. As the individual ages, brain volume decreases predominantly in the frontoparietal portion of the dorsal processing stream of the brain. Processing speed also begins to slow down. There is a negative correlation with the volume of the visual association area of the brain and the variability in processing speed for high to low feature load conditions (Müller-Oehring, Schulte, Rohlfing, Pfefferbaum, & Sullivan, 2013). These changes have a progressive impact on the individual's cognitive function. As the brain begins to age, there is a normal progression of cell growth and myelination and a standard regression of neuronal processes such as cell death and atrophy (Franke & Gaser, 2012). The brain has patterns that reveal why cognitive capacity degenerates over time. When a healthy brain undergoes its first years of life, grey matter volume rises only to be replaced by white matter. This will increase until around the age of twenty (Franke & Gaser, 2012). At this point the production of white matter comes to a standstill. This normal grey matter decay reveals a greater understanding of neurodegeneration. Due to the extensive research done on brain aging it is now recognized that maintaining brain health when one is younger is essential to preserve cognitive ability during the aging process. Research has supported the idea that an individual's IQ level can influence cerebral white matter hyperintensitites. Lack of care and low quality of education can negatively impact future cognitive aging success, while contributing to an increasing level of brain damage while aging (Valdés Hernández Mdel et al., 2013).

The current generation has been raised using computers and cellular phones. This has raised the question of whether the current dependence on technology is beneficial for our overall brain health and stimulation. Research in the field of brain health has suggested vital evidence pointing towards the importance of improving brain wellness. Mutual relationships between positive improvement in brain health and other lifestyle choices demonstrate an important connection. Studies have indicated that a balance between cognitive training and physical exercise will result in cognitive improvement. Specifically, physical activity has been highly regarded in supplying the brain with the essential levels of blood and oxygen necessary in order to protect it from cognitive decline. Additionally, Exercise is able to generate neuroplasticity and preserve neuro-cognitive elements (Hötting & Röder, 2013), signifying the importance of a healthy lifestyle and cognitive exercise. Studies have suggested that cardiorespiratory fitness can have an immense impact on the brain. Fitness has been related to enhanced cognitive functioning, increased neural vascularization, high levels of N-acetylasparate, and a rise in the hippocampal volume (Douw, Nieboer, Dijik, Stam, & Twisk, 2014). The hippocampus is the portion within the brain that forms, stores, and organizes memories. There have been many studies on the benefits exercise has on the hippocampus. After aerobic exercise was preformed over the course of a 1-year time period, the left hippocampus increased in size by 2.12 percent, and the right by 1.97 percent (Erickson et al., 2010). The control group that only performed stretching exercise routines indicated a decline of the hippocampus of 1.40 percent on the left side, and 1.43 percent on the right side (Erickson et al., 2010). The key to unlocking brain health is understanding the importance of an overall healthy lifestyle. Researchers encourage an array of healthy stylistic choices conducted in a consistent routine.

Physical exercise is not the only approach to keeping ones cognitive functions vibrant and healthy. Socialization is a form of mental exercising, and has been proven to improve working memory and other cognitive processes such as inhibition, and speed of processing. A study by Ybarra et al. (2008) proved that the experimental group out-performed the control group in these areas. The results also indicated that even short-term social interactions that lasted for about 10 minute were able to enhance the participant's cognitive performance (Ybarra et al., 2008). These experiments ascertained that elder and younger participants could mentally exercise their minds, and in return promote cognitive functioning (Ybarra et al., 2008).

In addition to fitness and socialization, meditation has also been proven to improve brain health. Through the use of functional magnetic resonance imaging, it has been determine what regions of the brain that are triggered by meditation (Lazar et al., 2000). While meditating (which includes focus and attention to a specific breathing pattern and repeating specific mantra) brain scans pick up an increase in attention and a personal control of the autonomic nervous system (Lazar et al. 2000). All of these lifestyle choices have been proven to have an advantageous impact on the brain. The evidence of these activities indicates the importance of not focusing on one mental stimulating activity alone. Having a connection to technologically based games unaccompanied by other activities are called into question by other mentally beneficial experiences.

With the advances in empirical research and relevant technology of the past century, the mysteries of the human brain have begun unfolding. While the apprehension of aging and illness is still something that individuals face as a natural reality of life, technologies have emerged that attempt to enhance brain health and cognitive function. Advancements today present opportunity

when assessing cognitive ability by creating stimulating games designed to target specific areas in the brain. With the use of electroencephalography to measure the neural signatures of cognition, researchers are able to determine that there was an enhanced attention and working memory ability when subjects performed specific memory and multitasking games. It also purportedly suggests that the prefrontal cognitive control system of the aging brain possesses robust levels of plasticity, and therefore gives one the ability to enhance cognition with games targeting these regions (Anguera et al., 2013). Concurrent with studies such as these, there has been an influx of products on the market, such as "Lumosity: Brain Game & Brain Training" claiming to improve cognitive abilities through games that allegedly incorporate neuroscience and cognitive research into their design. Lumosity provides a variety of games that claim to improve memory, speed, or problem solving skills (n.d.). The ultimate goal of each memory game is to improve proficiency in cognitive and memory skills. Regardless of the effectiveness of these games, each individual program generates tasks that challenge the mind with a series of tests and training exercises intended for self-affirmation. Stress has been proven to impair creativity and problem solving (Creswell, Dutcher, Klein, Harris, & Levine, 2013). Results from a study indicated that self-affirmation not only improved problem solving, but also enhanced academic achievement in other tasks and protected the mind from chronic stress (Creswell, Dutcher, Klein, Harris, & Levine, 2013). Due to the fact that technology has improved significantly in the past decade, opportunities are now available for people to avoid brain deterioration, improve brain plasticity, and encourage brain health. Taking the time to examine all the possible options to keep the mind active and healthy is very important. It is understandable that with the new advances in technology along with its simplistic and usually

enjoyable format, one might turn to computer games as a sole method of brain care. It has become increasingly important to examine all the studies that investigate the impact computer based memory games may or may not have on the brain.

METHOD

In order to fully understand the perception about computer based memory games, it is important to be familiar with the literature that investigates the effectiveness of memory computer games on cognitive improvement. The method used in this thesis included conducting a thorough literature review followed by a survey. The literature review included studies that investigated the effects of memory games on different participants of diverse age group with a large range of cognitive abilities. Following that, a survey was used to investigate older adults' views of those games. There were 90 male and female participants ranging from approximately 60 to 90 years of age. There were originally 115 participants in this study. However, 25 of the surveys had to be discarded for various reasons such as incompletion and participant error while filling out the survey. The participants used in the study were individuals over the age of 60, who were sampled from the LIFE@UCF group on the University of Central Florida Campus. The survey consisted of 7 questions. The questions gathered demographic information as well as information on the respondents' experience and perceptions of computer based memory games. It is important to note that these questions specifically asked for the participant's "perception" of each of the various factors. While the literature review sought to compile the prevailing findings on the effectiveness of brain games, the survey portion of this thesis was designed to assess the perception that the elderly have on various aspects of these games.

LITERATURE REVIEW

When researching the effectiveness of brain games, a multitude of studies and data must be considered. This is particularly important when analyzing the diverse evidence presented in each study, due to the varied style and approach, measurement techniques, methods, and participants used the experiments. However, outcomes regarding the effects memory games have on the brain remain controversial due to the conflicting results of many studies. The results of the literature review conducted are described below.

Studies that support the use of brain games suggest that improving quality of life, increasing children's aptitude in school, and being able to expand memory and attention can in fact be accomplished through scientifically designed games. One such example is the study conducted by Smith et al. (2009) which had the objective of testing the efficacy of brain computer training programs for older adults by comparing trained and untrained participants on measures of memory, attention, and participant-reported outcomes. This was a double-blind trial that had 2 participant groups, experimental and control. The participants in the experimental group used the computer program for 1 hour per day, 5 days a week, for 8 weeks, for a total of 40 hours of usage (Smith et al., 2009). The test were used to assess participants' neuropsychological status included auditory modality, neuropsychological evaluation of attention and memory, and reported outcomes from the participants (Smith et al., 2009). Results suggested improvements in both memory and attention. All of the measured portions of the experiment represented a sufficient increase in these values for individuals outside of the control group (Smith et al., 2009). Companies such as Lumosity have made claims that indicate their product has improved a participant's working memory and visual attention. In a study by Hardy,

Drescher, and Sarkar (2011) participants used Lumosity for about 29.2 sessions for about 20 minutes a day for a 5 weeks span of time (Hardy, Drescher, & Sarkar, 2011). The results indicated an improvement in the participants working memory, spatial memory, and visual attention. There was a reduction in the error of localization and visual stimuli recorded in addition to the training transfer of untrained measured cognition (Hardy, Drescher, & Sarkar, 2011). In a study by Peretz et al. (2011) healthy older adults were used as the participants in a double-blind study investigating the benefits of computer games geared towards cognitive training versus regular computer games that were not designed for cognitive improvement. Two groups were given a computer game over a three-month period of time. One group was given a personalized game to improve memory, whereas the second group played a non-personalized game (Peretz et al., 2011). The results showed that both groups of participants were able to increase their cognitive abilities, indicating the benefit that computer games had. The subjects that used the personalized computer game excelled more in visuospatial learning, working memory, and in focus attention than the other group (Peretz et al., 2011). Lee et al. (2013) constructed a study that used a computer based cognitive training system designed specifically for elder subjects. This experiment's main focus was to improve the quality of life in the senior citizens (Lee et al., 2013). After an 8-week program that involved 24 half hour memory game challenges, data suggested improvement in many different cognitive skills (Lee et al., 2013). There was amelioration in the scoring of attention, delayed memory, immediate memory, visuospational, and constructional abilities. Exit surveys filled out by the participants implied that the program was generally commended for its simplistic user-friendly format and overall enjoyment (Lee et al., 2013).

In addition to the improvement of general cognitive function, research has been published to support the efficiency of memory games in remediating specific brain ailments. In a study by Kesler, Lacayo, and Jo (2011) 23 cancer survivors aged 7 to19 who underwent radiation, surgery, or chemotherapy as a treatment method were the participants of the study. The cognitive rehabilitation period was over the course of 8 weeks, which comprised of a 40-session curriculum. (Kesler, Lacayo, & Jo 2011). The subject spent 25 to 45 minutes and played about 3 to 15 Lumosity games during each session (Kesler, Lacayo, & Jo 2011). The results expressed an increase in cognitive flexibility, verbal and visual declarative memory scores, processing speed, and pre-frontal cortex activation (Kesler, Lacayo, & Jo 2011). These studies point to the plasticity of the human brain as evidence for its ability for improvement through different training exercises. Computer-aid has been used as a method of cognitive improvement for individuals with multiple sclerosis. A study by Plohmann et al. (1998) used computer-aid programs on 22 participants with multiple sclerosis for 12 memory game sessions (Plohmann et al. 1998). This disease of the nervous system impairs memory and attention throughout the progression of the disease. The results showed an improvement in attention for a 9-week evaluation. The patients also reported a decrease in attention related issues they faced on an everyday basis (Plohmann et al. 1998). A study similar to this conducted by Solari et al. (2004) used 82 multiple sclerosis patients as participants in a randomized, double-blind controlled trial. The study was created in order to demonstrate the effectiveness of memory and attention computer based games. The only improvement that occurred was in the word list generation test provided for the subjects. The participants who used the games in the 16-session 8-week trial improved 45 percent over their initial scores (Solari et al. 2004). The overall consensus was an

improvement in minor memory tests results. However, no conclusive evidence was discovered to support the notion that these games were effective (by Solari et al. 2004).

In order to further understand the evidence that supports memory games, it is essential to identify the objectives of these memory games. Lumosity's product includes a series of online games and puzzles that allegedly work on several areas within the brain, using different types of games for diverse kinds of neurological improvement. As the marketing team of Lumosity stated, these games "train" and "exercise" your brain (Lumosity, n.d.). Since the launching of the site in 2005, Lumosity has become the figurehead in internet-based memory games. In fact, this online phenomenon has a subscription of over 35 million people, and has grown 150 percent each year since its release (Day, 2013, para 5). The head of communications for Lumosity, Erica Perng stated, "Lumosity is based on the science of neuroplasticity, the idea that the brain can change and reorganize itself given the right kinds of challenges" (Day, 2013, para 7).

Since Lumosity's release, there has been an influx of research conducted on training the working memory. During the experiments, the games in Lumosity and their goals are replicated and reconstructed to test individuals' abilities to improve specific kinds of brain function. For example, the experiment: "Improving fluid intelligence with training on working memory" (2008) was conducted with memory games in order to thoroughly test improvements in individual fluid intelligence levels within dynamic systems. The study defines fluid intelligence as solving problems with logic and solving new problems that are different from previously obtained knowledge stored in the brain (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). This experiment was conducted on 70 young participants, and had the individuals' sessions range from between 8 to 19 pre and post-test sessions, and 4 different training groups (Jaeggi,

Buschkuehl, Jonides, & Perrig, 2008). The memory game consisted of two different tests. The first was a training test that was comprised of 6 visual blocks and 6 auditory targets in the game. The second game was a transfer test, which tested fluid intelligence. The game increased difficulty, and required visual analogy. The problems contained a pattern, where one of the sequences was missing. The results showed a significant improvement in all the group's performance in working memory tasks. Fluid intelligence levels improved significantly in all three groups as well. While the control group also demonstrated improvement, the results were inferior to the groups that received training and were expected by the researchers due to the test retest principle (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008). The study illustrated that the fluid intelligence increase was training-related and not due to the participants own working memory or intelligence level. Therefore, this study indicated that the brain games fluid intelligence improvement had a transfer effect, and the use of the games improvement was particularly high (Jaeggi, Buschkuehl, Jonides, & Perrig, 2008).

"Enhancing visual attention and working memory with a web-based cognitive training program" (2011) was conducted to directly test participants playing Lumosity. The test was broken up into different assessments that tested and trained the individuals in categories such as visuals, forward and reverse spatial working memory, and spatial working memory (Hardy, Drescher, Sarkar, Kellett, & Scanlon, 2011). Each category used actual Lumosity programs in order to grasp the functional capabilities of this program. The results pointed to the participants improving more substantially than the control group that remained untrained. The Lumosity program was able to reduce the non-central visual stimuli and error in localization. The spatial working memory also improved performance levels components (Hardy, Drescher, Sarkar,

Kellett, & Scanlon, 2011). There was a significant training transfer of the skills acquired in Lumosity to the untrained actives that contained evidence of cognitive ability components (Hardy, Drescher, Sarkar, Kellett, & Scanlon, 2011). The feedback from the participants resulted in positive remarks, and the organization and structure of the website was a major contributing factor to motivate participants in retraining (Kesler, Sheau, Koovakkattu, & Allan, 2011). Benefits that video games have on multiple age groups is acknowledged in a study by Anguera, et al. (2003), which explains the benefits that the video games have on two diverse age groups. One group was 60 to 85 years of age versus the group of 20 year olds that remained untrained in the specific game being tested (Anguera et al., 2013). The adapted version of "Neuroracer" was used in the training exercise over the course of a 6-month study. The results indicated that participants surpassed the control group, but more importantly, the experiment was able to demonstrate improvement in attention and working memory- two elements that remained untrained in the multi-tasking experiment and training simulation. This study gave way to findings on the plasticity of the prefrontal cognitive control system that can be detected in an aging brain. (Anguera et al., 2013). The videogame was found useful in improving cognition, understanding cognitive abilities, and calculating neural mechanisms (Anguera et al., 2013).

A study conducted by Ball et al. (2002) administered a randomized controlled trial on elderly adults in order to assess the long or short-term effect of improving cognitive abilities, and the potential relevance these improvements could have to living independently. A sample size of 2,832 participants was broken up into four groups. Each group focused on either memory training, reasoning, or processing speed tests, while the control group that did not receive any contact (Ball et al., 2002). The results support the "effectiveness and durability" of the cognitive

training in improving targeted cognitive abilities (Ball et al., 2002). The cognitive functions that are required for "everyday" life were tested for this particular experiment. The results showed significant improvements compared to the baseline results over the course of 2 years. There was an 87 percent increase in speed, 74 percent increase in reasoning, and a 26 percent increase in memory improvements (Ball et al., 2002). The age bracket of 65 years and older appeared to manifest the most improvement while using the brain training online exercise programs. However, when the everyday functioning ability of the subjects were tested, the results indicated that there were no transfer effects disclosed after the 2 years mark. Shu-Chen et al. (2008) in a study of transfer task actively attempted to determine if participants improved their memory for the specific task at hand, or if an overall transfer of cognitive abilities in everyday life occurred. This study observed examples of transfer task activities. However, the trial indicated that the positive shared tasks in the study and the dual n-back did not transfer to any of the complex tasks that were screened. It was determined that more studies need to be conducted on dual n-back results (Shu-Chen et al., 2008).

As these studies gain traction, researchers attempt to replicate several of them to see if statistically significant improvements in fluid intelligence can occur. In a recent study titled: "No evidence of Intelligence Improvement After Working Memory Training: A Randomized, Placebo-controlled Study" (2013), a new light was shed on previous results recorded on alternative experiments with very similar scenarios. This trial recognized the past findings of others that have tested memory games, and decided to reexamine their positive improvement of intellectual scores. This experiment made sure to create a more rigorous and intense training regiment than the previous experiments they based off. 75 subjects completed 20 sessions of

adaptive dual n-back programs, which means they were studying the working memory of this training group (Redick et al., 2013). The participants were also required to take a pre-test, mid-test, and post-test that measured their multitasking capability, working memory, fluid intelligence, perceptual speed, and crystallized intelligence through out the entire experiment (Redick et al., 2013). After the completion of the experiment there was an improvement on the dual n-back visual tests. However, there was no positive transfer of the cognitive ability tests. Therefore, there was a lack of evidence to support that fluid intelligence had improved after the completion of the experiment (Redick et al., 2013). This study was designed specifically to combat the evidence of a positive improvement of intellectual scores after the use of memory games. Researchers argued that the studies that are used to support memory games have limitations in the designs and procedures of the tests. For example, the inconsistent transfers in the same tasks (but not all of them within the studies), a deficiency in theoretical foundation when attaining a mechanism accountable for the observed transfer, and the weak design of the experiment that was not conclusive enough to provide statistically significant results (Redick et al., 2013). Owen et al. (2010) conducted a study that is characteristic of the evidence ascertained against the effectiveness of brain games on cognitive abilities. This study indicated that there was an improvement in the tasks at hand, but the "benchmark" (Owen et al., 2010) cognitive tests had no significant improvement. In a six-week study with 1,1430 adults, participants were allocated to three groups that were trained in several tasks. One group focused on reasoning, while the second group delt with short-term memory, mathematics, visuospatial skills, and attention training. The third group acted as the control answering a questionnaire (Owen et al., 2010). The results of this study indicated that every participant trained with cognitive tasks

improved their ability to complete the specific, but their cognitive function remained the same as the control group. The memory games only improved ability in the task, which appears as an improvement in the individual's intelligence level. Researchers have conducted experiments that prove the lack of evidence found of transfer effects to untrained tasks, regardless if the tasks were cognitively closely related (Owen et al., 2010). Thompson et al. (2013), conducted a study in order to better understand fluid intelligence, and its ability to improve or remain unchanged after youth. The study consisted one group given 20 sessions with dual n-back training programs on working memory, and a separate group given 20 sessions of attentional programs for a 6-month period of time (Thompson et al., 2013). The pre and post measurements were on standardized intelligence, processing speed, reading abilities, and fluid intelligence. When both groups' results were examined, there was an improvement on the tasks that were specifically trained. However, when the groups were compared to a control group of untrained participants, there was no evidence that represented a transfer of improvement on the skills that were not trained (Thompson et al., 2013). Therefore, this study was unable to support that training adaptive working memory in younger adults improves working memory capacity in the untrained skills, cognitive abilities, or fluid intelligence (Thompson et al., 2013). The results of this study stand as a contradiction of the results found in other studies that claim their studies indicate a transfer effect.

Cost, labor, and time effective methods of cognitive enhancement have become part of today's educational approach. Studies have suggested the in person education and computer based education are equivalent to one another in terms of benefits. In "Learning mnemonics: A preliminary evaluation of a computer-aided instruction package for the elderly" 62 elderly

participants, that were on average 71 years of age were trained using a Computer-Aide Instruction program only online. A group of 218 elderly subjects were educated in a standard classroom environment. The participants partook in memory training exercises designed in a mnemonic method. The results of the two groups had small differences between them. Therefore, both methods appeared to have had similar effects on the subjects. Computer-aid programs may be the quick and less laborious method of educating (Finkel & Yesavage, 1989). In a study by Ijsselsteijn, Nap, Kort, and Poels (2007), self-efficacy had major benefits when using computer games for elderly users. There are therapeutic consequences, increased computer literacy, and self-efficacy improvements in relation to general technology. The stimulating brain games, and the accomplishments that occur will generate a significantly large self-esteem boost- an invaluable causation for senior citizens from computer-aid games. This is especially true, when a lack of self-efficacy has been linked to computer anxiety for elderly users (Ijsselsteijn, Nap, Kort, & Poels 2007).

SURVEY PROCEDURE

The opportunity to contribute to an undergraduate thesis was announced to a large group of potential participants, giving each of them the opportunity to volunteer their time to fill out the one page questionnaire (see appendix). The announcement made consisted of instructions, the general format of the survey, and the portion that required their perception about memory games. The first three questions were demographic including the age of the participant, gender, and highest level of education starting from first grade. The next two questions asked the participant if they have ever played a memory game, and how frequently they played them. The answers ranged from everyday to never played before. The next two questions involved a ranking scale from 1 to 5 that gave the participants the ability to provide their opinion about memory games. The questions asked about their perception of the game's complexity, and the effectiveness in improving memory. The last two questions on the survey allowed participants to voice any personal opinion they have about memory games. They could choose to explain why they quit any specific game they played in the past. Additionally, they could share any news or information about computer based memory games.

RESULTS

DESCRIPTIVES

The results were input into frequency tables. The table indicates that a total of 90 participants were surveyed. Thirty-six of the participants were male, which accounted for 40 percent of the subjects, and 54 were female, which accounted for 60 percent of the total. Out of the 90 total responses, 52 individuals indicated that they had played memory games, which account of 57.8 percent. Thirty-eight individuals reported having never played a computer-based game that claims to improve memory, which accounted for 42.2 percent of the participants. These results indicate that the survey contained more females then males. It also signified that participants who played memory games out numbered those who didn't. The frequency of playing these memory games was ranked according to the number of times that participants played (from every day, a few times a week, a few times a month, tried but rarely play anymore, and never playing before). The results suggested that 33 participants have never played memory games, and 16 played every day. Thirteen individuals play a few times a week, 8 play a few times a month, and 20 stated that they rarely play anymore. The crosstab results in provide the frequency of playing the game correlated to gender. The results indicated that males played more often than females. The mean age of the participants was 73.16 (SD=6.50). The mean number of years of education was f 15.56 years (SD=2.78). The mean for perception of game simplicity was 3.156 (SD=1.04), and for game effectiveness was 3.29 (SD=.97).

INFERENTIAL ANALYSES

In order to assess the results, a bivariate correlation analysis was conducted on the data collected from the surveys. The analysis revealed significant correlations in gender, education, and frequency of playing, and other factors. The results indicated that gender was correlated with the amount of years of education the participants had (r= -0.251, p=0.017), with male respondents having more years of education than female respondents. Gender was also correlated with how often one played games (r= -0.306, p=0.003) with males playing the games more often than females. The number of years of education was correlated with how simple or complex one views the games (r=-0.277, p=0.008). Those with more years of education saw the games as simpler. Whether or not one played these games was correlated with how simple or complex one viewed them (r=0.218, p=0.039). Players viewed the games as simpler than non-players viewed them. How often the games were played also correlated with how simple or complex one views the games (r=0.213, p=.043). The more often the game is played, the simpler the player views them. How often one played also correlated with how effective the player perceived the game to be (r=-0.381, p=.001). The results demonstrated that the more frequently one plays, the more effective one views the games.

A 2 X 2 multivariate analysis of variance was conducted on the data with gender (Male or Female) and player (Player or Non-Player) as the between subject variables, and simplicity and effectiveness as the dependent variables. The analysis indicated that there were no main effects, but there was a significant overall interaction effect between gender and player ($F_{(1,1)}$=3.50, p=0.04). Tests of between subjects effects indicated that the interaction effect for simplicity was significant ($F_{(1,1)}$=6.78, p=0.011) whereas the interaction effect for effectiveness was not. A test

of simple effects indicated that for simplicity, female respondents who did not play the games viewed them as more complex than those who did play ($Mean_{FemPlay}$=2.83, $Mean_{FemNonPlay}$=3.79). However, male players did not differ from male non-players with their simplicity ratings.

DISCUSSION

The goal of the literature review was to analyze the sources, and investigate the evidence for or against the effectiveness of computer based brain games. However, with a topic of this significance, conflicting perspectives within the results will inevitably occur. Computers have begun to take over for many activities that were once conducted in-person. Therefore, it is understandable that individuals will look to technological products for brain stimulation. The memory and cognitive based computer games have captivated a large group of people, and created a new craze about the importance of brain health and significance of memory protection. Through this, companies have introduced products in hopes to attract users that are interested in their mental wellbeing.

The sources within the literature review illustrated the improvements in memory and cognitive skills as a result of memory games played. Studies presented the increased scores achieved in each game over a period of time. There was an evident increase in the level of skill reached, and a great deal of positive remarks about the enjoyment the games gave the players at the end of the trial. The studies highlighted the positive correlation that the games can have on all ages and mental capabilities. When games were personalized towards the specific player and their capabilities, the outcome indicated a significant improvement in performance. The studies tested various skills that are trained in many computer-aid memory games. Loss of memory is a pronounced fear that many aging adults are concerned about. As we age other factors also inhibit successful aging. Therefore, memory games commonly improve skills such as speed, attention, mental flexibility, problem solving, and memory throughout their games. These companies remind subscribers of these fears by assessing their improvements in these categories, as well as

e-mailing their users about the dangers of loosing these cognitive functions. Studies conducted on cognitively impaired participants showed improvements in their results, as well as in the functioning of untrained tasks. Participants, especially cancer survivors, showed a continuous decline of mental capabilities as they age. Individuals in the study that used programs to train and stimulate their minds were able to show an increase in their cognitive abilities and recovery rates. According to the studies, the use of participants with rapid decline in all mental aspects caused indisputable results.

However, the mind is a complex organ with many facets that need to be examined from different perspectives. Memory cannot only be determined by scores and achievements displayed by a result table in a game. Several studies have generated evidence that indicated the brain's ability to improve specific tasks. In other words, the brain has the amazing ability to adapt and train in order to complete tasks more efficiently through practice and repetition. There are several individual games (with different cognitive objectives) within most products. Regardless of playing it several times, each game is designed to appear new and dissimilar from the previous session. However, the game's intention, procedure, and directions stay the same every time. After an extensive period of repetition, the brain will be trained in that specific task. These studies not only claim that the individual's score will improve, but also the memory's capacity. However, some studies claim that the improvements are not always transferable to skills necessary outside of the game. Additionally, some studies disregarded the improvements as a phenomenon associated with brain training. Memory game companies thrive off the idea that memory games will help your everyday life, and therefore have attempted to disprove these theories.

Long before computer based memory games were created, other natural forms of cognitive improvement existed. Exercise, socialization, relaxation, and personal contentment are all interconnected. Each of the activities is important when performed alone in stimulating the brain, but when they stand together it becomes even more beneficial for the brain's wellbeing. Playing memory games may improve your performance, scoring, and even expand your brain's plasticity. Evidence has suggested each individual activity listed creates their own specific benefit to the brain. Exercise has been linked to an increase in the hippocampal volume, and has even been tied to evidence of memory improvements. These activities are not only free, but can also be performed at any age. Many studies have discovered a negative reaction that older individuals have towards computers and electronics. A significant increase of stress was detected, which could lead to undesirable effects on participants of the games.

A survey was conducted on a group of elderly participants in order to grasp a general perception that this age group has in relation to memory games. All the research has emphasized the importance of brain protection during aging. It is crucial to stimulate the mind from a young age, but preservation through stimulation is vital in the aging years. By choosing this specific age group it was the intention of this study to understand their opinion of brain games. Education, age, and gender were important factors in correlating the results. The results of the study indicated that males in the study had more years of education than the female participants. This finding also led to the frequency that each gender played the game. Males generally played memory games more frequently than the female subjects. This finding may connect the amount of education to the importance the males put into their cognitive care and upkeep. Further research would need to be conducted in order to reinforce that connection. Education also

indicated a correlation of the subject's perception of the game's simplicity. The results implied that the more education that was obtained correlated to the game being perceived as simpler. This statistically significant correlation may indicate that individuals with more education may have an easier time playing the games. The educated subjects may view the game as more accessible and possibly user-friendly. However, this correlation does not assure that individuals with more education are benefiting more from these games or scoring high results, in comparison to individuals with less education. Extensive research on this correlation, using different methods would be necessary to determine this kind of connection. Other findings demonstrated that those who have played memory games in the past saw them as simpler. This could indicate a correlation to an individual's apprehension or anxiety when using the computer. This demonstrates that people who have never played before assume that it is too complex to grasp, and therefore an unappealing method of brain stimulation. These findings are similar to the results of how effective the player views the game. Evidence suggested that the more frequently the game is played, the more effective the results are. This could lead to the idea of self-efficacy, and self-esteem caused by the positive assurance of their improvement. This provides encouragement and makes revisits from the player more likely.

The correlations and connections made in the discussion are all speculative. In order to generate a more definitive connection about the subjects, it would be imperative to have a larger group of subjects in future studies. It is also vital to reiterate and further explain the subjects used in this study. LIFE@UCF is a program designed for continuous education through aging. The members are highly dedicated to expanding their minds, and increasing their knowledge. The members are typically independent and motivated individuals. The LIFE@UCF

group could cause a biased outcome. This is especially true when comparing the subjects who live in nursing homes versus independent elders who are not motivated in their continuous education.

To conclude, while the effects of memory games on cognitive improvement will continue to be researched and debated, it is clear that simply playing brain games alters individuals' perceptions of the games' effectiveness and simplicity. The positive correlations identified in this thesis could point towards an increase in individuals' self-efficacy, or one's confidence in their own abilities. Self-efficacy and overall self-confidence are vital factors that contribute to brain health. Maintaining the wellbeing of one's brain should not only lie with memory and cognitive games that improve skill, but also in multiple brain stimulating activities that have the capacity to improve one's overall mental health. The substantial cost increase concerning medical care and lifestyle changes for an aging individual makes online memory games a cost effective option for brain health. Along with the potential direct benefits to cognitive function, brain games increase self-esteem, reduce stress, and perhaps most importantly, promote interest in caring about brain health.

APPENDIX:

Survey

APPENDIX

Please answer the following questions by either filling in an answer or circling the correct one:

1. What year were you born? _____

2. What is your gender? Male or Female
   (Circle one)

3. How many years of education have you had? _____
   (Start counting from first grade)

4. Have you ever played a computer game that claims to improve memory or cognition?
   (Circle one) Yes or No

5. How often do you play?

   a) Every day
   b) A few times a week
   c) A few times a month
   d) I tried them, but I rarely play anymore
   e) I've never played them

6. On a scale of 1-5 (where 1 is Simple and 5 is Complex) how would you rate these programs in terms of simplicity?

   _____:_____:_____:_____:_____:_____

   1 2 3 4 5

   Simple Complex

7. On a scale of 1-5 (where 1 is Not at All Effective and 5 is Very Effective) how well do you think these programs work to improve memory?

_____:_____:_____:_____:_____:_____

1 2 3 4 5

Not at All Effective Very Effective

8. If you've tried these games and quit, please tell us why you quit.

9. If there is anything else you want to share with us about these games, please do it right here:

REFERENCES

Anguera, J.A., Boccanfuso, J., Rintoul, J. L., Al-Hashimi, O., Faraji, F., Janowich, J., . . . Gazzaley, A. (2013). Video game training enhances cognitive control in older adults. *Nature*. 501(7465): 97–101. doi: 10.1038/nature1248

Ball K, Berch D. B., Helmers K.F., Jobe, J.B., Leveck, M. D., Marsiske, M., . . . Willis, S. L. (2002). Effects of Cognitive Training Interventions With Older Adults: A Randomized Controlled Trial. *JAMA,* 288(18):2271-2281. doi:10.1001/jama.288.18.2271.

Buschkuehl, M., Jaeggi, S. M., Hutchison, S., Perrig-Chiello, P., Dapp, C., et al. (2008) Impact of working memory training on memory performance in old-old adults. *Psychol Aging* 23(4): 743–753.

Creswell, D. J., Dutcher, J. M., Klein, W. P. R, Harris, P. R., & Levine, J. M., Self-Affirmation Improves Problem-Solving under Stress**.** *PLoS ONE,* 2013; 8 (5): e62593 DOI:10.1371/journal.pone.0062593

Day E. (2013, April, 20). Online Brain-Training: Does It Really Work? *The Guardian*. Retrieved from http://www.theguardian.com/science/2013/apr/21/brain-training-online-neuroscience-elizabeth-day

Douw, L., Nieboer, D., Van Dijk, B. W., Stam, C. J., & Twisk, J. R. (2014). A Healthy Brain in a Healthy Body: Brain Network Correlates of Physical and Mental Fitness. *Plos ONE*, *9*(2), 1-8. doi:10.1371/journal.pone.0088202.

Erickson, K. I., Prakash, R. S., Voss, M. W., Chaddock, L., Hu L., Morris, K. S. . . Kramer, A. F.

Aerobic fitness is associated with hippocampal volume in elderly humans. *Hippocampus*. 2009;19:1030–1039.

Gray, J. R., Chabris, C. F. & Braver, T. S. Neural mechanisms of general fluid intelligence. Nature Neurosci. 6, 316–322 (2003).

Hardy, J. L., Drescher, D., Sarkar, K., Kellett, G., & Scanlon, M. (2011). Enhancing visual attention and working memory with a web-based cognitive training program. *Mensa Research Journal*, 42(2), 13–20.

Hötting K, & Röder B. (2013). Beneficial effects of physical exercise on neuroplasticity and cognition. *Neurosci Biobehav Rev*. doi:10.1016/j.neu-biorev.2013.04.005.

Kesler, S.R., Lacayo, N.J., & Jo, B. (2011). A Pilot Study of an online rehabilitation program for executrive function skills in children with cancer-related brain injury. *Brain inj*. 25(1):101-12. doi: 10.3109/02699052.2010.536194.

Kesler, S. R., Sheau k., Koovakkattu, D., & Allan, R. L. (2011). Changes in frontal-parietal activation and math skills performance following adaptive number sense training: Preliminary results from a pilot study. *Neuropsychological rehabilitation*, 21, 433-454, doi:10.1080/09602011.2011.578446.

Finkel, S. I., & Yesavage, J. A. (1989). Learning mnemonics: a preliminary evaluation of computer-aided instruction package for the elderly. *Exp Agining Res.* 15(3-4): 199-201.

Franke, K., & Gaser, C. (2012). Longitudinal changes in individual BrainAGE in healthy aging, mild cognitive impairment, and Alzheimer's disease. *Geropsych: The Journal Of Gerontopsychology And Geriatric Psychiatry*, *25*(4), 235-245. doi:10.1024/1662-9647/a000074

Lazar S., Bush G., Gollub R., Fricchione G., Khalsa G., & Benson H. (2000). Functional brain mapping of the relaxation response and meditation. *Neuroreport*. 15;11(7):1581-5.

Lee T., Goh S. J. A., Quek S. Y., Philips R, Guan C, Cheung Y. B., . . . & Krshnan K.R., 2013. A brain-computer interface based cognitive training system for healthy elderly: a randomized control pilot study for usability and preliminary efficacy. *Plos One*. 8(11):e79419. doi: 10.1371/journal.pone.0079419. eCollection 2013

Lumosity. (n.d.). Retrieved from http://www.lumosity.com/landing_pages/509?gclid=CI2y28Dw5r0CFahlOgodZEoAMA

Müller-Oehring, E. M., Schulte, T., Rohlfing, T., Pfefferbaum, A., & Sullivan, E. V. (2013). Visual search and the aging brain: Discerning the effects of age-related brain volume shrinkage on alertness, feature binding, and attentional control. *Neuropsychology*, 27(1), 48-59. doi:10.1037/a0030921

Ng, N. F., Sternberg, D. A., Katz, B., Hardy, J. L., & Scanlon, M., (2013). Improving Cognitive Capacities in School-aged Children:A large scale, multi-site implementation of a web-based cognitive training program in academic settings. *Lumos Labs Inc*.

Ng, N.F., Sternberg, D. A., Katz, B., Hardy, J. L., & Scanlon, M. D. (2012). New Approaches to Learning Using Neuroscience and Gaming: A large scale, multi-site implementation of a web-based cognitive training program in academic settings. *Lumos Labs Inc*.

Owen, A. M., Hampshire, A., Grahn, J. A., Stenton, R., Dajani, S., Burns, A. S., & Ballard, C. G. (2010). Putting brain training to the test. *Nature*, *465*(7299), 775-778. doi:10.1038/nature09042

Peretz C., Korczyn A. D., Shatil E., Aharonson V., Bimboim S., & Giladi N (2011). Computer-based, personalized cognitive training versus classical computer games: A randomized double-blind prospective trial of cognitive stimulation. *Neuroepidemiology* 36(2): 91–99.

Plohmann A, Kappos L, Ammann W, Thordai A, Wittwer A, Huber S., . . . & Lechner-Scott J. (1998). Computer assisted retraining of attentional impairments in patients with multiple sclerosis. *J Neurol Neurosurg Psychiatry*. 64(4): 455–462.

Shu-Chen, L., Schmiedek, F., Huxhold, O., Röcke, C., Smith, J., & Lindenberger, U. (2008). Working Memory Plasticity in Old Age: Practice Gain, Transfer, and Maintenance. *Psychology & Aging*, *23*(4), 731-742. doi:10.1037/a0014343

Smith, G. E., Housen, P., Yaffe, K., Ruff, R., Kennison, R. F., Mahncke, H. W., Zelinski, E. M. (2009). A cognitive training program based on principles of brain plasticity: Results from the improvement in memory with plastivity-based adaptive cognitive training (IMPACT) study. *J Am Geriatr Soc.*, 57(4): 57(4):594-603. doi:10.1111/j.1532-5415.2008.02167.x.

Solari, A., Motta A., Mendozzi, L., Pucci, E., Forni, M., Mancardi G., & Pozzilli, C. (2004). Computer-aided retraining of memory and attention in people with multiple sclerosis: a randomized, double-blind controlled trial. J Neurol Sci. 15;222(1-2):99-104.

Ijsselsteijn, W., Nap, H. H., Kort, Y. D., Poels, K. (2007) Digital game design for elderly users. *ACM*

Jaeggi, S. M., Martin, B., Jonides, J., & Perrig, W., J. (2008) Improving fluid intelligence with training on working memory. *PNAS*;doi:10.1073/pnas.0801268105

Redick, T. S., Shipstead, Z., Harrison, T.L., Hicks, Fried, D.E., Hambrick, D.Z. . . & Engle, R.W. (2012) No evidence of intelligence improvement after working memory training: a

randomized, placebo-controlled study. *J Exp Psychol Gen*; 142(2): 359–379. doi: 10.1037/a0029082

Thompson, T. W., Waskom, M. L., Garel, K. A., Cardenas-Iniguez, C., Reynolds, G. O., Winter, R., & . . . Gabrieli, J. E. (2013). Failure of Working Memory Training to Enhance Cognition or Intelligence. *PLoS One*. 2013; 8(5): e63614. doi: 10.1371/journal.pone.0063614

U.S. Census Bureau (2011) *Statistical abstract of the United States: 2011*. Washington, D.C.: Government Printing Office.

Valdés Hernández Mdel, C., Booth, T., Murray, C., Gow, A. J., Penke, L., Morris, Z., . . . Wardlaw, J. M. (2013). Brain white matter damage in aging and cognitive ability in youth and older age. *Neurobiology Of Aging*, 34(12), 2740-2747. doi:10.1016/j.neurobiolaging.2013.05.032

Ybarra, O., Burnstein, E., Winkielman, P., Keller, M., Melvin, M., Chan, E., Rodriguez, J. (2008) Mental Exercising Through Simple Socializing: Social Interaction Promotes General Cognitive Functioning. *Pers Soc Psychol Bull.* DOI: 10.1177/0146167207310454