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The Impact of a Video Game Intervention on the Cognitive Functioning, Self-Efficacy, Self-Esteem, and Video Game Attitudes of Older Adults

A final project submitted to the Faculty of Claremont Graduate University in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Psychology

by

Giovanni W. Sosa

Claremont Graduate University

2012

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APPROVAL OF THE REVIEW COMMITTEE

This dissertation has been duly read, reviewed, and critiqued by the Committee listed below, which hereby approves the manuscript of Giovanni W. Sosa as fulfilling the scope and quality requirements for meriting the degree of Doctor of Philosophy in Psychology.

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Abstract

The Impact of a Video Game Intervention on the Cognitive Functioning, Self-Efficacy, Self-Esteem, and Video Game Attitudes of Older Adults

by

Giovanni W. Sosa

Claremont Graduate University: 2012

While a well-established body of empirical work indicates that engaging in mentally stimulating activities is linked to positive physical and mental health outcomes, relatively few studies have specifically examined the impact that video game training can have on cognitive functioning and well-being. Given the substantial implications that such work has for an ever-growing older adult population, this area of research has begun to pique the interest of researchers world-wide.

The present study employed an experimental paradigm to explore the impact of a Nintendo DS video game, *Brain Age*, on the cognitive functioning, self-efficacy, self-esteem, and video game attitudes of adults aged 65 and older. A total of 35 participants were recruited from various Senior Centers located in the San Fernando Valley and were randomly assigned to an intervention group that played Brain Age for five weeks (three hours of supervised training per week) or a control group that was only required to complete an assessment battery before and after a five week period. Findings stemming from ANCOVA analyses in which pre-test scores (and in the case of cognitive outcome variables, a separate cognitive screener) served as covariates indicated significant group differences with regards to brief arithmetic and syllable count assessments, and marginally significant differences on the basis of the Stroop Interference Test. While all the effects for self-efficacy, self-esteem, and a newly developed video game attitudes scale were in the predicted direction, no statistically significant group differences were found. Findings across the 16 examined outcome variables also indicate larger effects among cognitive outcome variables that are directly practiced via the intervention. Such findings also indicate larger effects among timed over non-timed cognitive measures, and among cognitive over affective/attitudinal variables. Notwithstanding limitations concerning the transferability of trained skills to a broader set of cognitive abilities, the current study's evidence suggests that playing a simple, inexpensive, and easily accessible videogame can enhance some aspects of cognitive functioning. These findings hold significant implications for the millions of older Americans looking for technologically-oriented avenues by which to sharpen their cognitive skills.

Dedication

To God -

The only one I know that does not

need confidence intervals to understand the

world we live in.

Acknowledgement

I would like to thank all of my committee members for their insightful feedback on this project: Dale Berger, William Crano, Jason Siegel, and Luciana Laganá. I am particularly grateful to both Dale Berger and Luciana Laganá – I could write books about how much I have learned from each of you over the years. I am forever indebted to you.

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Lastly, I would like to acknowledge God. I have not attended a religious service in years, but if I learned anything from overseeing this project and navigating the myriad of challenges I encountered along the way, it is that what appears impossible can be made possible with effort and faith.

Table of Contents

List of Tables

List of Figures

List of Appendices

Chapter 1: Introduction

The U.S. population is aging rapidly. While adults aged 65 or older comprised 12.4% (35 million) of the population in 2000 (U.S. Bureau of Census, 2003), they are expected to comprise over 19% (72 million) of the population by the year 2030 (National Institute on Aging, 2005). This means that there will be a large increase in the number of Americans who face the cognitive impairments associated with aging. Age-related cognitive impairment is characterized by difficulties associated with perception, memory, and motor function (Broadbent, Cooper, FitzGerald, & Parkes, 1982). While minor impairments are often missed without the use of proper screening tests (Rami, Molinuevo, Sanchez-Valle, Bosch, & Villar, 2006), even minor impairments in individuals free of any form of dementia have been often linked to declines in psychological functioning (Wong, Wetterneck, & Klein, 2000). For example, Lagana` and Sosa (2004) found that, among women aged 65 or older, minor cognitive impairment was more strongly associated with depressive symptoms than being widowed or having low socioeconomic status. According to the National Health Interview Survey (Bernstein & Remsburg, 2007), four percent of non-institutionalized adults aged 65 to 74 years experience mild or moderate cognitive impairment (e.g., confusion or memory loss). However, this percentage increases to nine percent for individuals aged 75 to 84 years, and to almost 20% for people aged 85 and older. Meanwhile, as of 2008, approximately 2.2 million (67%) of nursing home residents were experiencing some form of cognitive impairment (Alzheimer’s Association, 2010). While problems resulting from minor cognitive impairment often interfere with psychological well-being, such negative outcomes are clearly exacerbated by more severe forms of cognitive impairment, such as Alzheimer's disease (Devi, 2004). In fact, Alzheimer's disease is by far the most common and severe form of dementia, affecting approximately 4.5 million Americans (National Institutes of Health, 2007).

Historically, older age has been perceived as a time of inevitable physical and cognitive decline (Lynch, 2000; Palmore, 2003). However, there is a growing belief among the public that older adults can retain cognitive abilities and perhaps even experience cognitive improvements as a result of engaging in mentally and/or physically stimulating activities (Hertzog et al., 2009). In line with this "Use it or Lose it" perspective, between 30% to 40% of adults aged 65 or older responding to an open-ended question about how they control their memory specifically mentioned engaging in mentally stimulating activities (Hertzog et al., 2009). Indeed, a growing body of work indicates that engaging in mentally stimulating activities is linked to positive physical and mental health outcomes (Baltes, Lindenberger, & Staudinger, 2006). While research in this area has examined the efficacy of an assortment of mentally stimulating activities, such as reading and playing an instrument (Verghese et al., 2003), the majority of work has relied on self-report rather than on observational or experimental work (see Salthouse, Berish, & Miles 2002 for a review). Most work in this area, both cross-sectional and longitudinal, has historically involved asking individuals to rate their perceived levels of engagement in a range of mental activities (e.g., reading magazines, completing cross-word puzzles). For instance, Bosma et al., (2002) tracked 830 individuals between the ages of 49 and 81 from 1993-1995. All participants were free of neurological conditions (e.g., dementia) as well as mental retardation, and none were taking psychoactive medication. Participants were asked to report their levels of engagement in mentally active tasks (such as playing chess) at the beginning and end of the three-year period. Findings indicated that, at both phases, participants engaging in such activities demonstrated greater cognitive functioning than did individuals not engaging in such activities. This effect was found even after statistically adjusting for gender, age, and educational level. While correlational in nature (it is also possible that those who possess greater levels of cognitive functioning already engage in a greater number of mental activities), these findings point to the meaningful relationship that exists between mentally stimulating activities and cognitive functioning.

1.1 *Examining the Efficacy of Video Games*

Experimental work on the efficacy of mental stimulation among older adults is sparse, and the work that does exist is focused primarily on offering older adults non-technology oriented training (Baltes & Lindberger, 1988; Hertzog et al., 2009). Many examples of such work are in the area of memory research (Ball et al., 2002; Li et al., 2008; Willis et al., 2006). Willis et al. (2006) conducted a five-year study in which older individuals were randomly assigned to treatment or control conditions. They found that a 10 session memory training program had a significant impact on memory ability, and more compelling, these effects remained apparent after the full five-year period. While there is a clear line of work examining the efficacy of non-technology oriented memory training among older adults, less work has specifically examined the role of video and computer games.

According to Hertzog et al. (2009), it is difficult to prove that using a computer training program or a game leads to improved brain function, as the effect sizes for cognitive-enrichment effects are small in relation to the large individual variability in cognitive functioning. However, while work specifically examining the impact of video game interventions on older adults' cognitive functioning is still relatively sparse, it has consistently found a positive link between such interventions and cognitive performance (Basak, Boot, Voss, & Kramer, 2008; Dustman et al., 1992; Farris, Bates, Resnick, & Stabler, 1994). In one study, experimental subjects who trained for two months twice a week in 1.5 hour sessions in the use of an arcade-type videogame achieved significant positive gains on the WAIS-R (d = .89) and on eye-hand coordination (d = 1.02; Drew & Waters, 1986). Meanwhile, Goldstein et al. (1997) discovered that, in a small sample of 22 community-dwelling older individuals residing in Holland (aged 69 to 90), those who trained at home for 5 hours per week for 5 weeks on Nintendo's Super Tetris improved their scores on Card Sorting Tasks (White & Cunningham, 1987), in contrast to those not receiving training (d = 1.75). In more recent work, Tarraga et al. (2006) conducted a randomized pilot study with 46 cognitively impaired older adults living in Spain. They found that those playing a computer game designed to enhance cognitive rehabilitation for a period of 12 weeks (3 weekly 20 min sessions) demonstrated less cognitive impairment on the Mini-

Mental State Examination (Folstein, Folstein, & McHugh, 1975) immediately after the 12 week intervention period (*d* = .32) and the benefits were still present at a 12 week follow-up (*d* = .47). Moreover, others have found that training (in 15 training sessions of 1.5 hours each over 4 to 5 weeks) in a real-time strategy computer game (an adapted version of a commercially available game called Rise of Nations) led to improvements, at post-test, in areas such as task switching (*d* = 1.02), working memory (*d* = .82), and reasoning (*d* = .55; Basak, Boot, Voss, & Kramer, 2008). Lastly, there is evidence that playing computer games is associated with an increased release of dopamine (involved in learning and a reinforcement of behavior) in the brain (Koepp et al., 1998), and that playing games has a high potential for the rehabilitation of motor abilities among those experiencing motor deficits (Cameirao, Bermúdez, Badia, Duarte Oller, Zimmerli, & Verschure, 2007).

1.2 *Key Issues Involving Video Game Interventions*

In reviewing the available evidence examining the link between gameplay and health outcomes, Gamberini, Barresi, Majer, and Scapetta (2008) concluded that game training serves as a viable intervention by which to enhance older adults' cognitive abilities and decrease their chances of experiencing psychological problems stemming from illnesses and isolation. However, while most recent research points to a positive link between playing video games and beneficial health outcomes, many prior studies in this area were conducted using outdated games or customized games that are not available to the public. The implication is clear: while empirical work may indeed suggest the efficacy of such video games in fostering increased cognitive functioning, the fact that such games are not widely available means that few individuals stand to directly gain from the potential advantages of the examined video games. It is possible that there are commonalities among empirically examined games, and that those commonalities may be generalizable to a host of similar games, some of which are widely available. Nevertheless, there is currently not enough empirical evidence to establish the plausibility of that assertion; that is, it is too early to determine whether benefits derived from one specific video game can indeed be generalized to an entire genre of games. Given the lack of work attempting to establish the benefits in cognitive functioning among genres of games, video game interventions making use of widely available games stand to have a more profound impact on a broader spectrum of older adults than a specialized game not publicly available. Thus, a commonly available game that has been empirically shown to have an impact on well-being possesses greater real-world implications – that is, it can impact a greater number of individuals – than a game that is in limited production.

Another key issue is the extent to which the skills older adults acquire in the game are transferable to other tasks not directly practiced in the game (Hertzog et al., 2009). If the skills and abilities older adults acquire from using the game are specific to only the specific tasks practiced in the game then that calls into question the generalizability of the benefits derived from playing the game. That is, for one to experience broad gains in cognitive functioning, one would have to potentially engage in an assortment of mentally stimulating tasks and/or games. If the generalizability of the skills acquired via games is limited, that would suggest that video games have only a superficial impact on cognitive abilities; rather than affecting core underlying cognitive mechanisms with broad-based gains in various cognitive skills, games may simply serve as tools to sharpen very specific skill sets via extensive practice. On the other hand, if games are found to have broad-based impacts on cognitive functioning, with specific gaming activities associated with gains on an array of cognitive outcomes – both those practiced and not practiced – then such findings would lend credence to the notion that games can serve as robust tools for improving cognitive functioning. Especially meaningful would be the finding that the skills acquired via video games have a direct bearing on improving everyday lives of older people. The fact is that adults aged 65 or older are five times more likely than adults under age 65 to require assistance in performing Activities of Daily Living (ADLs), such as self-grooming, basic money management, and meal preparation (Heller, Hemming, Kohnert, & Feldman, 1986). Given the projected increase in the number and percentage of people 65 and older, it stands to reason that increasing numbers of older adults will experience functional limitations over the next several decades. Therefore, interventions that harness the power of technology to enhance older adults' functional independence are greatly desirable due to highly generalizable real-world impact that they could have on the lives of older people. From this standpoint, not only would games then serve as tools for enhancing a multitude of cognitive skills, but also as tools that could maintain older adults' quality of life and potentially prevent mild cognitive impairment, dementia, or even Alzheimer's disease.

Research on the transferability of the skills acquired via cognitive training is mixed. Much of the work in this area suggests that skills learned via cognitive training do not transfer to other outcome measures (Baltes & Lindenberger, 1988; Hertzog, 2009). Baltes and Lindenberger reported gains in cognitive skills that were directly practiced among older adults. However, there was minimal evidence indicating that gains on tasks that were directly practiced transferred over to a broader set of tasks, leading the authors to conclude that cognitive training interventions should not be expected to transfer to wide-ranging cognitive outcomes. More recently, Ball et al. (2002) recruited over 2,800 independent-living individuals between the ages of 65 and 94 from various sites, including Senior Centers and senior housing sites. Individuals were randomly assigned to one of three intervention groups or to a no-contact control group. The three interventions focused either on enhancing memory, reasoning, or speed of processing; participants assigned to such groups completed 10 training sessions. Results indicated small to large gains (*d*s ranging from .26 to 1.5) across each of the three groups on the corresponding outcome measures (i.e., memory training and performance on memory outcome measure; reasoning training and performance on reasoning tasks). Nevertheless, the authors did not observe the transfer of gains to the other outcomes measures; that is, no gains in reasoning or speed of processing was observed among older participants in the memory training group.

On the other hand, there is also empirical work suggesting a transferring of skills to outcome measures other than the ones directly practiced by participants. For instance, Wolinsky et al. (2006) recruited over 2,800 adults 65 years or older and randomly assigned them to either one of three interventions groups described in Ball et al. (2002) or to no-contact control group. Results indicated that participants assigned to the speed of processing group (but not the memory or reasoning intervention groups) demonstrated a decreased likelihood of experiencing decline in health-related quality of life (adjusted odds ratio = .64). Li et al. (2008) offers yet another example suggesting the transferring of skills resulting from cognitive training. The authors recruited 41 older adults and assigned them to a cognitive training condition or a control group. While the control group was only asked to complete both the pre and post-tests, the intervention group was asked to complete 45 training sessions (one per day, 15 min each) in addition to completing the pre and post assessments. The outcome assessments included a memory assessment directly tied to the training sessions, a memory assessment that was similar in cognitive processing demands (described as a near transfer task), two complex memory span tasks not thought to share the same processing demands as the near tasks (described as far transfer tasks), and two decision speed tasks which were designed to minimally tax working memory. Findings indicated that, compared to the control group, participants demonstrated significant gains in performance (as defined by decreases in reaction time) on the task directly tied to learning (d = 1.95), and on a near transfer spatial task (d = 1.54). Lastly, as described earlier, Basak et al. (2008) found robust differences across several outcome measure purported to measure wide-ranging cognitive skills (i.e., task switching, working memory, and reasoning). The video game intervention the authors employed was a real-time strategy game requiring participants (all adults aged 65 or older) to coordinate a host of cognitive processes to maintain information in short-term memory and effectively shift attention between various stimuli so as to make decisions concerning resources and gaming strategies. It is possible that the extensive use of various coordinated cognitive skills resulted in the observed gains across a host of outcome measures. Thus, while most studies point to small or non-existent transfer effects, preliminary research indicates that cognitive training that goes beyond the practicing of specific skills and focuses on the coordination among complex cognitive strategies seems to be associated with broad-based gains in cognitive functioning. Given the limited literature on the topic, especially as it pertains to video game interventions, this is an area that clearly warrants further study.

Finally, one issue that has not been discussed in relation to the impact that video game interventions have on cognitive functioning is with respect to the nature of the outcome measure itself. Broadly speaking, the measures used to assess the impact of cognitive interventions can be classified into two categories: (a) speed of processing measures, and (b) accuracy measures. While the former entails timing (usually with a stop watch or computer device) length of time to complete an assessment, the latter focuses on the number of correct responses. The Card Sorting Tasks and the MMSE (described earlier) are examples of each assessment type, respectively. The decline in cognitive processing speed observed with age is among the most widely-observed behavioral phenomena of aging, with a plethora of work indicating a linear decline in cognitive processing speed across age (Salthouse, 1996). According to Salthouse, it is in fact the decline in processing speed that leads to cognitive impairment in late life. Given such evidence, it is possible that video game interventions have more of an impact on timed measures of cognitive ability than on measures of accuracy. Although, as is the case when considering the transferability of skills stemming from participation in video game interventions, the extent to which performance on timed measures, or measures of accuracy, are affected by video games may depend on the relative exposure users have on tasks that are inherently timed tasks versus accuracy tasks. More work is needed before any definitive conclusions can be drawn.

1.3 *Perspectives for Why Video Games Can Improve Cognitive Functioning*

Cognitive Enrichment Hypothesis. The current evidence suggests that cognitive functioning can be improved in older age via interventions employing video game technology. An overarching perspective that guides this research, and one that specifically describes the malleability of late-life cognition in the context of individual differences, is the *Cognitive Enrichment Hypothesis* (Hertzog et al., 2009). This framework acknowledges the upper and lower limits of cognitive functioning that are shaped by (a) person-specific developmental histories and inherited traits, and (b) biological aging. According to this perspective, the malleability of late-life cognition stems from the interaction between individual differences resulting from genetic and experiential factors, and biological changes caused by the "normal" process of aging. Hence, the extent to which a given cognitive intervention can impact cognition depends upon the upper boundaries of cognitive functioning possessed by participants, which themselves are shaped by individual differences and age-related cognitive decline. For instance, Baltes and Kliegl (1992) conducted an intervention study in which 35 healthy younger adults (aged 20-30yrs) and 19 healthy older adults (aged 66-80yrs) were compared on the basis of a word recall task after receiving 38 training sessions specifically designed to enhance the encoding and retrieving of word lists from memory. Findings indicated gains in word recall among both groups, suggesting cognitive plasticity among both younger and older individuals. However, results also indicated a robust difference between age groups ($d = 1.47$). Similar age differences have been found across many studies (see Hertzog et al., 2009 for a review). Thus, while such findings support the notion that older adults are fully capable to enhancing their cognitive functioning, they also support the view that older age brings about normal declines in cognitive functioning that are not amenable to training. Although older adults may no longer possess the cognitive ability of younger adults, they still have the potential to enhance (or further worsen) their level of cognitive functioning. In line with the Cognitive Enrichment Hypothesis, an intervention could improve older adults' cognitive functioning, particularly if its target population is non-institutionalized participants with little or no cognitive impairment; that is, those who likely possess higher limits of cognitive functioning.

Cognitive Engagement. Video game training offers participants an interactive, engaging learning experience characterized by a high degree of user control and immediate feedback. These aspects of technology have been shown to be beneficial in the context of technology-based learning (Sosa, Berger, Saw, & Mary, 2011), and they may also be pertinent to how video games may facilitate cognitive improvement. For instance, computer-assisted instruction allows users to control the pace at which information is presented, increasing not just user's engagement with the computer-based tool, but also learning (Frederickson, Reed, & Clifford, 2005; Gonzalez & Birch, 2000). Likewise, computer-assisted instruction offers students feedback, which has been found to be most effective when goals are clearly defined and feedback is highly related to attaining the goals in question (Hattie & Timperly, 2007). The value of feedback is further increased when it indicates achievement/progress with current activities and leads students through activities required to accomplish specified goals (Hattie & Timperly, 2007). In the same way, video games, particularly those designed to foster learning or increase cognitive functioning, also offer users the ability to control the pacing of the gaming experience. Given the immersive experience that video games offer (McMahan, 2003), it stands to reason that engagement fostered by games may help to increase learning and cognitive functioning. In addition, the feedback that video games offer helps to foster effective learning strategies by helping users monitor progress towards a specified goal. Thus, such cognitive engagement may facilitate older individuals' ability to reach their maximum cognitive operating level, as described by the Cognitive Enrichment Hypothesis.

1.4 *The Link Between Video Games, Attitudes, Self-Efficacy, and Self-Esteem*

Attitudes. While current research points to the potential efficacy of video game training, relatively less attention has been placed on examining the attitudes that older adults hold regarding video games, and how those attitudes may be linked to the efficacy of video game interventions. Research also points to a positive link between computer technology training and older adults' attitudes concerning computer instruction (McNeely, 1991). Such training has been found to be related to the reported intention to use computers in the future (Eilers, 1989), and prior experience with computers is significantly related to better attitudes towards computers in the general population (Anderson, 1996) and among older adults (Kerschner & Chelsvig Hart, 1984; Krauss & Hoyer, 1984). Such work indicates that older adults have a less favorable opinion of videogames than do younger adults (McClure, 1985); in addition to citing lack of interest, older adults point to a lack of perceived need for videogames (Belchior, 2007). On the other hand, as is the case of computer game training, videogame training has a seemingly positive influence on older adults' attitudes toward this technology (Belchior, 2007). Because more positive attitudes toward computerized technology are significantly related to better health status (Jay & Willis, 1992; Menec & Chipperfield, 1997), video game technology training could have many positive benefits for older adults. In fact, such findings suggest the possibility that cognitive improvement associated with video game training may, at least partially, be accounted for by the attitude changes associated with video game training.

Self-Efficacy and Self-Esteem. A plethora of work has found that individuals' beliefs about their capacity to affect their environments are strongly linked to their health and cognitive performance (Bandura, 1989, 1993; Bandura & Locke, 2003; Holden, 1991; Multon, Brown, & Lent, 1991). Cognitive functioning is highly influenced by the beliefs that people hold regarding how/whether cognitive ability changes over time; individuals who perceive cognitive abilities as inevitably declining with age are more likely to exert less effort in attempting to maintain their abilities and they are more likely to view poor performance as indication of such decline. In contrast, those who believe in the malleability of cognition (and in their ability to affect their environments) are more likely to exert greater effort in maintaining their abilities and in exerting effort in the face of poor performance (Bandura, 1993; Wood & Bandura, 1989a). In turn, those exerting a high degree of effort exhibit improved cognitive performance over those exerting less effort (Bandura, 1993). Similarly, the stronger one's self-efficacy, the more likely one is to set high personal goals for oneself (i.e., achieve milestones in the video games) and the more likely one is to remain committed to achieving such goals, despite less than ideal performance; these perceptions, coupled with the corresponding effort, have been linked to improved cognitive performance (Bandura, 1989, 1993).

In line with the Social Cognitive Theory (Bandura, 1977), individuals who persist in challenging activities are likely to acquire personal mastery experiences (in the case of videogame training, confidence in one's abilities). According to Bandura, believing that one is capable of achieving success at a task (such as successful videogame playing) is a cognitive process that enhances an individual's sense of environmental control, even in the face of limitations imposed by common age-related losses, such as reduced cognitive abilities. Based on this conceptualization, individuals' self-efficacy perceptions translate into greater cognitive effort that, in turn, also results in greater feelings of control and cognitive functioning.

Changes in cognitive abilities are not only linked to personal control, but also to self-esteem. Billipp (2001) found that engaging older adults in a successful and rewarding experience with technology, such as training them on computer use, increased their sense of control and self-esteem. One reason why self-efficacy and self-esteem may both be affected by a cognitive intervention is that both constructs may reflect a higher order common construct (Judge, Erez, Bono, & Thoresen, 2002). While self-efficacy and self-esteem have been viewed historically as theoretically distinct constructs, Judge et al. (2002) reported that meta-analytic findings from 75 studies published between 1966 and 2000 indicated that these two constructs are highly correlated (r = .60). Additionally, based upon confirmatory factor analyses of primary data gathered by Judge et al., strong fit indices were found when the individual constructs were allowed to load on a higher-order model. Coupled with the poor fit obtained in the model that did not allow the individual constructs to correlate with a second-order factor, their findings suggest that a single core construct accounts for the relationship that exists between self-esteem and self-efficacy. Lastly, using the Multitrait-Multimethod Matrix (MTMM) approach (Campbell & Fiske, 1959; Crano &

Brewer, 2002), Judge et al. found poor discriminate validity between the constructs, further bolstering the viewpoint that they reflect a single common core construct.

One limitation of the research conducted by Judge and others is that their findings are primarily based upon younger adults. In fact, little is known about how cognitive functioning is related to self-efficacy or perceived sense of control in older age (Hertzog et al., 2009) and a search of the literature did not uncover any studies that directly examined videogame use in relation to older adults' self-efficacy. Yet, self-efficacy may be enhanced following the achievement of cognitive gains via videogame training. One intervention study reported that engaging in interactive computer-based education was found to increase the sense of personal control in long-term care residents (McConatha, McConatha, & Dermigny, 1994). Additionally, there is some evidence that older adults with a history of hip fracture who undergo virtual reality exposure therapy report an enhanced sense of control (Giotakos, Tsirgogianni, & Tarnanas, 2007). And lastly, a higher sense of self-efficacy has been found to be associated with higher levels of cognitive functioning (Berry, 1999; Hess, 2005). Thus, it is plausible to expect that a videogame intervention would be found to be associated with gains in self-efficacy; however, direct empirical support is lacking.

1.5 *Summary*

Despite the fact that the literature specifically examining the impact that video games has on cognitive functioning among older adults is limited, there is enough published work to conclude that video games serve as a potentially viable option for older adults (particularly healthy and community-dwelling older adults) looking to enhance their cognitive abilities. In line with the Cognitive Enrichment Hypothesis, older adults seemingly possess the plasticity necessary to derive several cognitive benefits from playing video games. However, much of the current research was done with now dated video games and/or games that are not commercially available to the public. In addition, there is still a great deal of uncertainty regarding the extent to which the skills acquired through video game training impacts specific or broad-based cognitive functioning. It is possible that the increased engagement and feedback technology-based tools offer may serve to enhance the transferability of the skills acquired though video games; however, such transferability may hinge upon the nature of the video game in question and on the level of process coordination required by the user to effectively play the game. A related issue has to do with understanding the extent to which the nature of the outcome variable is associated with larger or smaller gains in studies examining the impact of video games on cognitive functioning. Given that age is closely tied to decreases in cognitive processing speed, it is possible that video game interventions generally have a greater impact on timed assessments than they do on non-timed cognitive assessments.

While video game researchers have largely focused on potential gains in cognitive functioning, there is research linking gains in cognitive functioning to self-efficacy. Given the strong theoretical link between self-efficacy and self-esteem, it is possible that video game interventions specifically aiming to improve cognitive functioning may also serve as viable tools for enhancing self-efficacy and self-esteem. Video game attitudes have also been studied, with most research suggesting that older adults' experiences with playing games is positively associated with more accepting views of video games. Thus, as in the case of the aforementioned variables, it is possible that participation in a video game intervention will lead to more positive views concerning the perceived utility of video games.

1.6 *The Current Studies and Hypotheses*

The current studies presented herein were designed to examine the extent to which a video game intervention employing the use a widely available and portable video game could affect older adults' both cognitive functioning and psychological variables (i.e., self-efficacy, self-esteem, and attitudes). In doing so, it heeds the call to conduct empirical work on commercially available resources marketed by businesses as cognitive enrichment tools (Hertzog et al., 2009). In addition, findings stemming from these studies would help further elucidate issues pertaining to the transferability of cognitive abilities as well as explore the extent to which a video game intervention could impact both cognitive functioning and affective/attitudinal variables (i.e., self-efficacy, self-esteem). Given the limited work examining the links between personality variables, it stands to reason that video game training is more closely tied to cognitive outcome measures than it is to personality variables. Lastly, the current studies collectively examined the impact that video game training has on a host of cognitive outcomes, both timed outcome variables (i.e., time to complete a task) and non-timed variables (i.e., number of errors, number of correct responses); thus, findings stemming from these studies would help further clarify the extent to which video game training differentially affects timed outcome variables compared to non-timed variables.

The first study represents a pilot investigation designed to gather the preliminary evidence necessary to refine and expand research protocols. Beyond the logistical considerations (e.g., form close partnerships with local Senior Centers; enhancing the training of research assistants), a critical issue was to explore (at a preliminary level) whether a focused video game intervention has a larger impact on (a) outcome measures directly tied to the video game training, (b) on timed outcome measures, and (c) on cognitive outcomes rather than affective/attitudinal outcomes. In addition, the first study allowed for the reliability testing of newly developed cognitive measures as well as a video game attitudes scale.

The same hypotheses apply to the second study. However, the second study was designed to use the findings and implementation experiences stemming from the initial study to enhance the methodological rigor observed in the first study via, among other things, the employment of random assignment to conditions, the inclusion of additional outcome measures, and increased experimental control over the overall time intervention participants spent playing video games.

Chapter 2: Study 1

2.1 *Participants*

A total of 31[1] community dwelling older adults were recruited from two Senior Centers located in Southern California (*Mean Age* = 78.19, *SD* = 7.17). Participants were recruited through community contacts via convenience and snowball sampling procedures. Research assistants conducted the assessment and training sessions at either a local Senior Center or at locations chosen by the participant. Study protocols were approved by the CSUN Standing Advisory Committee for the Protection of Human Subjects (see Appendix C for a copy of the consent form).

Inclusion Criteria. In order to participate in the study, participants must have met the following criteria: (a) be age 65 years or older; (b) be fluent in English; (c) obtain an adequate score on a cognitive impairment screening test; (d) be free of epilepsy, severe arthritis, carpal tunnel syndrome, or Parkinson's disease; (e) live independently (i.e., not residing in an assisted care facility); and (f) be able to provide informed consent (i.e., in addition to being fluent in English, they were also required to understand the terms stipulated in the consent form).

Rationale for Inclusion Criteria. Many of the inclusion criteria were designed to recruit only subjects who could benefit from our intervention and employ this training in the future. To this end, we included only older adults residing outside institutional settings because individuals living in institutional

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[1] Thirty-five participants were originally recruited; however, four (two from each treatment group) withdrew from the study before completing the post-test assessment.

facilities are more likely to exhibit neurological/cognitive conditions that could impair their ability to learn to use videogames. Due to the very unlikely risk (1 in 4000) of suffering a seizure or blackout during game playing (Nintendo of America, 2006), as a precaution, we included only older adults without a history of epilepsy or seizures. There does not appear to be any empirical literature specifically on the link between video game use and seizures among older adult populations, so the risk may be greater or lower for these individuals. Seizures among older adults have been found to be highly linked to dementias (Martin, Griffith, Faught, Gilliam, Mackey, & Vogtle, 2005). However, given our cognitive impairment screener, it was unlikely that a participant with dementia severe enough to be a risk factor for seizures would have been included in the study. Additionally, holding the Nintendo DS for the duration of one hour per session may be difficult for individuals with severe arthritis or Parkinson's disease who, for this reason, were not allowed to participate in the study. Lastly, adequate vision was required in order for trainees to read directions, navigate the game's menus, and complete the mini-games.

2.2 *Materials*

The study examined the possible improvement in cognitive functioning and subjective well-being among older adults playing Nintendo's Brain Age, a portable video game designed to sharpen player's cognitive skills (See http://www.nintendo.com/consumer/gameslist/manuals/DS_Brain_Age.pdf to access the complete instructional manual). Brain Age is composed of an assortment of mini-games and puzzles designed to engage players mentally through the use of the Nintendo DS's touch screen and microphone. Such mini-games and puzzles include, among other games (a) the *Stroop Test*, which requires players to verbalize the color of a word instead of its semantic meaning; (b) *Calculations x20*, which requires players to manually write down (on the touch screen) a response to each of 20 arithmetic problems; (c) *Syllable Count*, which requires players to write down the number of syllables that correspond to each of several phrases presented on the screen; and (d) *Sudoku*, a puzzle game that presents players with a 9x9 grid of numbers and requires players to complete the grid in a manner such that each column, row, and 3x3 box must contain each number from 1 to 9.

2.2 *Design and Procedure*

The Senior Centers were randomly assigned to either the treatment or control condition; consequently, participants recruited from a given center were assigned the center's assigned condition. All participants completed a pre and post-assessment separated by a 5-week period. Participants in the treatment condition played Brain Age five days per week (each day's session was for the duration of one hour) for a period of five weeks. While two of the five hours each week were monitored by the author or a research assistant, three hours were played alone by the participant. While asking participants to play alone may present a problem with compliance, participants' compliance with the training protocol was verified by checking the saved data on the Brain Age game, which tracks the dates that participants played the game as well as the specific mini-game(s) they completed. In contrast to the participants in the treatment group, participants in the control condition did not partake in any video game activities; they only completed the identical set of pre-post measures that the treatment group completed.

2.3 *Measures*

The pre-test battery included all the measures described below. The post-test battery included all except the screening questions. Each of the two assessments took approximately 30 minutes to complete. All measures can be found in Appendices A - M.

Physical Health Screener and Demographics. The *Health Background List* (Appendix C) is a 4-item adaptation of an existing health measure by Krause (1997). In accordance with the stated inclusion criteria, the questions ask participants to indicate whether they suffer from epilepsy, Parkinson's Disease, carpal tunnel syndrome, or severe arthritis in the hands. If respondents indicated experiencing any of these conditions, they were excluded from further participation. In addition, a brief questionnaire (Appendix D) assessed age, gender, ethnic background, education, and income.

Memory Alterations Test (MAT). The MAT (Appendix F) is comprised of 43 items that yield a total possible score of 50 points. It is a quick and easy-to-administer tool to assess cognitive impairment and early stage Alzheimer's Disease among older adults. Work conducted with adults aged 65 or older indicates that the tool possesses strong internal consistency ($\alpha = .92$; Rami et al., 2007) and is highly sensitive in correctly identifying cases of cognitive impairment. In fact, not only has it been shown to correctly distinguish between those suffering from minor cognitive impairment and early onset Alzheimer’s Disease, but also between those suffering from minor cognitive impairment and those without objective memory impairment (Rami, Bosch, Sanchez-Valle, & Molinuevo, 2009). The cutoff score of 37 has a high degree of sensitivity (.96) and specificity (.79) in identifying normal functioning older adults and older individuals suffering from minor cognitive impairment, comparing favorably to the Mini Mental State Examination (Folstein, Folstein, & Mchugh, 1975). However, one item (Item 26) was identified as being highly culturally sensitive and was removed from the version of the MAT employed in the current study. The cut-off score was still maintained at 37, meaning that research participants needed to obtain a score at least 37 to be allowed to participate in the study.

The Trail Making Test (TMT). The TMT (Appendix G; Reitan, 1958) is a brief tool commonly used to quantify motor function, visual scanning, and cognitive flexibility. It is widely considered a measure of general cognitive function. It has two tasks, Task A and B, with strong reliability on both parts indicated by internal consistencies (α) ranging from .80 to .96 (e.g., Spreen & Strauss, 1991). Both parts are comprised of 25 circles on a sheet of paper; in task A, the circles are numbered from 1-25, and participants are asked to draw a line connecting these circles in sequential order; in Task B, the circles are labeled by numbers (1-13) and by letters (A-L). As in Task A, in Task B subjects connected the circles in order, but in an alternating pattern between numbers and letters. Participants were asked to work as quickly as possible while maintaining their pen or pencil on the sheet. The dependent variables are the time it takes to complete the tasks and the number of errors that are documented after completion of the task. The TMT has been found to be reliable predictor of independent living abilities (e.g., essential self-grooming, cleaning) among healthy older adults (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000; Cahn-Weiner, Boyle, & Malloy, 2002). The distinction between parts A and B is of particular interest as Brain Age offers users practice with part B but not with part A.

Global Feelings of Control. The 4-item version of the Global Feelings of Control measure (Appendix K; Krause & Shaw, 2001) is a quick and reliable tool to assess general self-efficacy and perceptions of control among older adults. With items such as “I can do just about anything I really set my mind to” and “When I make plans, I’m almost certain to make them work”, the tool is designed to measure individuals’ perceptions about their ability to effectively perform behaviors necessary to actualize outcomes, a central aspect of self-efficacy (Bandura, 1977). The original authors found it to possesses strong internal consistency ($\alpha = .75$) among older adults.

2.4 *Results*

Table 2.1 illustrates demographic information among both the intervention and control groups. Groups were not compared on the basis of ethnic background because all but two participants (one in each condition) identified themselves as Caucasian. Control group participants were slightly older (*Mean Age* = 79.27, *SD* = 7.63) than treatment group participants (*Mean Age* = 77.24, *SD* = 6.83); however, this difference was not found to be statistically significant, $t(30) = -.80$, $p = .43$. In addition, no significant gender difference was found between groups

(ϕ = -.08, *p* = .67) and no significant differences was identified on the basis of education (*t* = -.20, *p* = .84). In addition, while the estimated median for the treatment group is higher (Median = $45,000) than that of the control group (Median = $36,000), that difference was not found to be statistically significant (*t* = -.97, *p* = .32).

To test whether these groups differed on changes from pre to post test, independent-samples t-tests on the gain scores[2] were conducted, one per dependent variable (see Table 2.2). Because each of the two cognitive outcome was measured in units of elapsed time (in seconds), it was hypothesized that the treatment group would demonstrate a greater decline in the amount of time to complete the task than would the control group. Findings indicated that with regards to the Trail-Making A Task, participants in the control group demonstrated a greater decline in time (M_d = -6.88, *SD* = 13.66) than did the treatment group (M_d = -2.81 *SD*= 13.90); however, this difference was not found to be statistically significant (*t*(30) = .84 , *p* = .41 ; *d* = -.29). Meanwhile, the treatment group (M_d = -16.00, *SD*= 40.78) participants demonstrated a greater decline in time than did the control group (M_d *= 1.75, SD* = 30.36) on the Trail-Making B Task; although, as was the case with the Task A, this difference was not found to be statistically significant (*t*(29) = 1.35 , *p* = .19; *d* = .87). Only two participants committed an uncorrected error on the task (one in each group); as

[2] While ANCOVA, with pre-test and demographic data serving as covariates, was considered a possible analytical strategy, much literature suggests that ANCOVA is inappropriate with non-equivalent group designs. See pgs. 43-47 for a more thorough discussion of gain scores and ANCOVA.

such, no analyses were conducted on those data. Moreover, while the treatment group was found to report a greater gain in feelings of control (M_d = *.71*, *SD* = 2.85) than the control group (M_d = -*.36*, *SD* = 2.26), no significant difference was identified ($t(29) = 1.31$, $p = .27$; $d = .48$).

Table 2.1

Demographic Characteristics Among Participants in Study 1 (N = 31)

Characteristic	Treatment		Control	
	N	%	N	%
Gender				
Male	6	35	6	43
Female	11	65	8	57
Education				
Less than high school	0	0	0	0
High School Graduate	2	12	4	29
Completed Trade School	2	12	1	7
Some College	8	47	4	29
Bachelor's Degree	4	24	3	21
Some Grad School	1	6	2	14
Master's Degree	0	0	0	0
PhD/MD/JD	0	0	0	0
Annual Income				
Less than $20k	2	12	2	14
$20 - $39k	5	29	7	50
$40 - $59k	3	18	0	0
$60 - $79k	3	18	2	14
$80 - $99k	0	0	0	0
$100 or greater	0	0	0	0
Refuse to Respond	4	24	3	21

Table 2.2

Mean Differences, Standard Deviations, and Effects Size ds for Treatment (N = 17) and Control (N = 14) Groups in Study 1

	Treatment Mean Diff (SD)	Control Mean Diff (SD)	*p*	*d*
TM-A	-2.81 (13.90)	-6.88 (13.56)	.41	-.29
TM-B	-16.00 (40.78)	1.75 (30.36)	.19	.87
Gen. Control	.71 (2.85)	-.36 (2.27)	.27	.48

2.5 *Conclusions*

Analyses stemming from Study 1did not point to any statistically significant differences between the treatment and control groups. However, findings indicate potentially meaningful differences with respect to both Task B and feelings of control. With regards to Task B, findings indicate that the average gain score earned by participants in the treatment group was higher then 81% of scores in the control group; while not statistically significant difference, this robust effect should not be ignored. This finding suggests that a video game intervention using Brain Age could potentially have a meaningful impact on cognitive functioning. Another important implication of this finding is with regards to examining the transferability of acquired skills. A relatively large difference was found on the directly practiced outcome (Task B), but not on a similar non-practiced task (Task A). This finding suggests that the benefits of using Brain Age may be limited to the specific skills that are practiced in the game, and the benefits derived from playing the game cannot be generalized even to a similar task (i.e., Task A). A potentially meaningful difference was also found with respect to personal control; findings indicate that the average gain among participants in the intervention group was higher than 69% of scores in the control group. As hypothesized, the effect for personal control was not found to be as robust as that of Task B; nevertheless, the effect for personal control is in the predicted direction, and is large enough to at least warrant further study.

In sum, preliminary findings indicated that participants in the treatment condition demonstrated the potential for meaningful gains with respect to their cognitive functioning and perceived well-being. While a limitation of this pilot study was that the Senior Centers – rather than the individual participants – were randomly assigned to conditions, it should be noted that no differences were found between the two groups on the basis of relevant demographic variables, such as income, gender, and educational background. The findings from the pilot study are considered promising inasmuch as they show the feasibility of a video game intervention with older adults, and with the potential for substantial effects on cognitive function, self-efficacy, and self-esteem. Lastly, such evidence supports the aforementioned hypotheses regarding the transferability of practiced skills and the increased gains in cognitive skills over gains in affective variables.

2.6 *Changes Incorporated into Study 2*

Several methodological and logistical changes were implemented for Study 2. Chief among them was the employment of random assignments of participants to conditions. Participants in Study 1 were not randomly assigned to conditions due to concerns both the author and Senior Center directors shared regarding the potential tension that may arise from the recognition of control participants that they would not be taking part in the video game intervention. These concerns were somewhat allayed via informal inquiry of both treatment and control participants after completion of Study 1; all participants unanimously agreed that no tension or conflict would result between those partaking in the intervention and those not partaking in the intervention. Another significant change was with respect the level of experimenter control over the time intervention participants spent utilizing Brain Age. As described earlier, the initial study required participants in the intervention group to complete five training sessions (one hour each), two under the supervision of the author or a research assistant, and three sessions independently. Brain Age keeps track the dates in which it was used, along with the specific mini-games that are played, it does not keep track of the duration of game-playing session, nor can it confirm whether it was indeed the participant that completed those games. To further standardize the intervention protocol, the second study required intervention group participants to complete three supervised sessions per week.

Another enhancement to the protocols was the inclusion of additional outcome measures into Study 2. In addition to the Trail-Making Tasks employed for Study 1, 11 more cognitive measures were added to the assessment battery and a self-esteem measure along with a video game attitudes assessment. Additional demographic assessments were incorporated conducted to gather more information regarding participants' level physical exercise and experience with mentally stimulating activities. Next, the specific game training procedures (i.e., the specific mini-games played, the creation of a profile) were further structured so as to further standardize the video game training experience of the intervention group participants. Lastly, given the increased number of outcome variables, along with goal of achieving increased statistical power, a slightly different statistical approach was employed in analyzing the data stemming from Study 2. All of these changes are described in greater detail in Chapter 3.

Chapter 3: Study 2

3.1 *Participants*

A total of 35 individuals[3] (Mean Age = 74.71, SD = 6.07) participated in the study. As in the pilot study, participants were recruited from local Senior Centers. In addition, participants were recruited through community contacts via convenience and snowball sampling procedures. Research assistants met with participants at either a local Senior Center or at locations chosen by the participant. Study protocols were approved by the CSUN Standing Advisory Committee for the Protection of Human Subjects (see Appendix D for a copy of the information form).

Inclusion Criteria and Rationale. Inclusion criteria were identical to those employed in Study 1 with the exception that all potential participants were asked if they would commit to the intervention protocols for five weeks, three times per week (1 hour sessions).

3.2 *Measures*

The pre-test battery included all the measures described for Study 1. The following measures are those that were incorporated into the assessment battery employed in Study 2. The post-test battery included all the assessment tools used in the Pre-test, with the exception of the cognitive screener (i.e., MAT), the demographics questionnaire, and the background experience measures (i.e., exercises participation and experience with mentally stimulating activities). The

[3] While forty participants were originally recruited, five participants (three from the control group and two from the experimental group) withdrew from the study.

pre and post-tests each took approximately 60 minutes to complete. All participants completed both the pre-test and the post-test assessment sessions in two 30-minute sessions, separated by a break, to minimize fatigue.

Two Physical Health Screeners. In addition to the Health Background List (described in Study 1; Appendix C), Study 2 also required participants to complete the 25-item *National Eye Institute Visual Function Questionnaire* (VFQ-25; Mangione et al., 2001), which is a self-report measure of visual function. It contains 12 sub-scales corresponding to a total summative score ranging from 0 to 100; individuals experiencing visual impairment typically obtain lower scores as compared to those not experiencing visual impairment (Jampel, Friedman, Quigley, & Miller, 2002). The VFQ's internal consistency is strong among older adults ($\alpha = .96$; Revicki, Rentz, Harnam, Thomas, & Lanzetta, 2010), and the empirically-derived cutoff score used in this study to identify those with visual impairment, is 83 (Owen et al., 2006).

Memory Alterations Test. This is the same assessment tool employed in Study 1, with the same cut-score of 37 (see Appendix F).

Demographics and Video Game Background. As in Study 1, a brief questionnaire inquired about age, gender, ethnic background, education, and income (see Appendix D). Additionally, three items were used to gather information on prior videogame use and videogame ownership (see Appendix E). Participants were also asked to indicate whether they had attempted and/or completed any cross-word puzzles or other puzzles (e.g., Sudoku) over the previous five weeks; as follow-up items, participants were asked to indicate whether such puzzles were completed via an electronic source, such as the computer/internet or a video game. Lastly, the Exercise Participation Scale (EPS; Roth, Wiebe, Fillingim, & Shay, 1989) was used to gather information regarding individuals' participation in physical or exercise-related activities over the course of the last three months. The EPS inquires about 12 different exercises or activities, including jogging, hiking/walking, and swimming. For every exercise/activity that participants reports engaging in, they are asked to indicate (a) the number of times they have, on average, engaged in that activity over the past week; (b) the average duration (in minutes) of each activity session; (c) the perceived intensity of a typical activity/exercise session using a 3-point scale (1 = low; 2 = moderate; 3 = high); and (d) the number of days per week that they engage in a moderate or high intensity session for at least 20 continuous minutes.

The Trail Making Test (TMT). Identical to assessment conducted in Study 1, both Task A and Task B were completed.

Raven's Advanced Progressive Matrices. Raven's Matrices Test (Raven, 1962; Raven, Court, & Raven, 1994) is measure of basic cognitive functioning and abstract reasoning. It was designed to examine the extent to which individuals can think clearly and make sense of complex information (known as "eductive" ability), and the ability to remember and reproduce information previously presented information (i.e., reproductive ability; Babcock, 1994; Raven, 2000). A large body of work has found this instrument to possess a high degree of reliability and validity among younger and older adults (Bors & Stokes, 1998; Babcock, 1994), and it has been employed with older adult populations (Basak, Boot, Voss, & Kramer, 2008). Each item is made up of a series of diagrams that follow a logical pattern; the diagram that would be in the final cell, however, is missing. The respondent is then asked to choose from among eight possible solutions in identifying the diagram that completes the pattern. The entire assessment is comprised of one set of 12 items (Set 1) and a second set of 36 items (Set II), with items within each set becoming increasingly difficult. Set I is often used a practice set for Set II since its 12 items are considered less difficult than those stemming from Set II. However, due to administration time constraints (40 min are required to complete Set II while only 5 min are required to administer Set I), the current study employed only Set I with a five min administration time.

The Mini Arithmetic Assessment (MAA). The MAA is a tool developed for this study, comprised of 20 basic arithmetic problems (seven addition, six subtraction, and seven multiplication exercises). Participants were asked to complete the MAA after first completing two practice exercises (one addition and one multiplication exercise). The time to completion (in seconds) was recorded along with the number of errors. Test-retest reliability among older adults was explored prior to implementation of Study 2 by having 10 volunteers recruited from a local Senior Center participating in Study 1 and 2 (all aged 65 or older) complete the assessment before and after a five week period. The correlation between pre and post-test scores was found to be $r = .81$, indicating adequate test-retest reliability. Individuals completing this pilot measure did not participate in either Study1 or 2.

The Mini Syllable Count Assessment (MSA). The MSA, developed for this study, is comprised of seven phrases for which participants were asked to indicate the number of syllables. Participants were first offered two examples (along with the correct answers) to illustrate task, after which point they were asked to complete two practice exercises. The seven phrases were completed only after the participant indicated understanding the task and completed the two practice exercises. The time to completion (in seconds) was recorded along with the number of errors. As with the MAA, the same 10 volunteers completed the MSA; the pre-post correlation was found to be r = .73, indicating adequate reliability.

The Card Sorting Tasks (CST). The CST (White & Cunningham, 1987) is a collection of reaction time measures commonly employed in studies of selective attention. Each task requires the use of a 52-card deck and the differences between the specific tasks lie in manner in which the deck is to be sorted. Card Sorting Task 1 (CST 1) asks participants to sort the cards into two piles based upon color; Card Sorting Task 2 (CST 2) requires sorting the cards into four piles by suit; and lastly, Card Sorting Task 3 (CST 3) asks participants to sort the cards into 13 piles according to rank. The Card Sorting Tasks have adequate to good internal consistency among adults aged 65 and older (e.g., α = .87 for CS1; α = .87 for CS2; and α = .60 for CS3; Tomer & Cunningham, 1993; White & Cunningham, 1987). In older age, scores on all three Card Sorting Tasks appear to be highly related to well-established measures of reaction time, such as the Sternberg Reaction Time Task (Sternberg, 1975) and the Perceptual Speed Test (Guilford & Zimmerman, 1948). A confirmatory factor analysis of various measures of speed (i.e., reaction time) yielded findings indicating that Card Sorting (as measured by the three distinct tasks described above) serves as one of the critical factors underlying cognitive processing speed among older adults (Tomer & Cunningham, 1993).

Stroop Test. The Stroop Test (Stroop, 1935) is comprised of three distinct reaction time tests that collectively measure selective attention. The first of these tests, the Color Patch Naming task, requires participants to name the colors (i.e., green, blue, and red) of color patches sequentially printed on a page as quickly as possible without skipping any or making mistakes. Participants are allowed a maximum of 90 seconds to complete the task. The total time (in seconds) is recorded along with the number of total errors (items to which the examinee did not respond because the time limit was reached are not counted as errors). The second test, the Word Reading task, requires participants to read aloud the words of colors (i.e., green, blue, and red) sequentially printed on a page as quickly as possible without making any errors. Participants are allowed a maximum of 90 seconds to complete the task. As with the Color Patch Naming task, the total time (in seconds) is recorded along with the number of total errors (items to which the examinee did not respond because the time limit was reached are not counted as errors).

The final test, the Interference task, requires participants to recognize that the words they are presented are in different colors. They are therefore required to say the color that color names are printed in rather than the words themselves. For instance, the word “Red” may actually be presented in blue ink, meaning that the correct answer is “Blue.” As with the previous tasks, participants are asked to read each item sequentially as quickly as possible. However, participants are allotted a maximum of 180 seconds to complete the task. The total time (in seconds) is recorded along with the number of total errors (items to which the examinee did not respond because the time limit was reached are not counted as errors). A plethora of work (see Jensen & Rohwer, 1966 for a review) has documented the reliability and validity of the Stroop Test, and several studies have examined cognitive function among older adults with this instrument (Barella, Etnier, & Chang, 2010; Graf, Uttl, & Tuokko, 1995; Liu-Ambrose, Ashe, Graf, Beattie, & Khan, 2008). As is the case with the Trail Making Test, the Stroop Test has been found to be reliable predictor of independent living abilities (e.g., essential self-grooming, cleaning, money management, meal preparation) among healthy older adults (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000).

Global Feelings of Control. Identical to that employed in Study 1.

The Rosenberg Self-Esteem Scale. The Rosenberg Self-Esteem Scale (Rosenberg, 1965) has been used previously with older research populations (e.g., Ranzijn, Keeves, Luszcz, & Feather, 1998); the scale consists of 10 items on 6-point Guttman scales measuring basic feelings of self-worth. Its Cronbach's α internal consistency is 0.74 among non-institutionalized older adults (Ward, 1977) and it has been found to be an appropriate scale to use for measuring global self-esteem in older age (Breytspraak & George, 1982).

Video Game Attitudes Scale. Positive attitudes towards videogames were measured via three Likert-scaled items developed for this study (e.g., “I like the idea of using videogames to improve my mental functioning”). The same 10 volunteers completing the MAA and MSA also completed the video attitudes scale. The pre-post correlation was found to be r = .67, indicating adequate reliability.

Gameplay Log/Checklist. A checklist was used to monitor progress made by each participant assigned to the treatment group. This one-page log/checklist was given to research assistants to keep track of the dates and specific mini-games participants completed.

3.3 *Design and Procedure*

As in Study 1, there was a treatment and control group. However, unlike the initial study, participants were randomly assigned to conditions individually. Before being assigned to conditions, potential participants completed the pre-test assessment. If they earned a sufficiently high score on the Memory Alterations Test (Cut Score of 37), they were contacted within 24 hours to be informed of their status in the study (experimental, control, or ineligible to continue). Each participant in the control condition completed the pre- and post-test battery during two one-on-one-meetings with the author or a designated research assistant, separated by five weeks to match the interval between these tests for the experimental group. There were a total of 20 intervention group participants and 15 control group participants. Each participant assigned to the experimental group trained/played Brain Age for three one-hour sessions per week for five weeks (15 hours total). However, to exercise tight control over videogame use, the trainer (i.e., author or research assistant) was present during each training session. To control the amount of time using the game, the trainer kept possession of the video game device after completion of each one-hour training session.

An additional enhancement over Study 1 was the increased structure of the game training protocols. Brain Age offers users several mini-games and game playing modes. In Study 1, participants in the intervention group were allowed to play any of the available mini-games they desired, and in any game mode (e.g., practice or the Daily Training Mode, requiring the creation of a permanent gamer profile). However, the focus in Study 2 was to structure the video game experience so as to ensure that all intervention participants had similar exposure levels to the game - not just in terms of the total amount of time spent playing the game, but also with respect to the specific mini-games and game modes, and in regards to the order in which such game content was presented. To that end, research assistants began by familiarizing participants with the three game modes offered by Brain Age: Quick Play, Daily Training, and Sudoku. After participants were familiar with the Quick Play Mode, they attempted Daily Training, which offers players access to nine mini-games (six of which are unlocked over time with continued play) along with Brain Age Check, which provides access to additional games and offers players feedback in the form of a "Brain Age" that varies from 20 (reflecting the highest level of achievement) to 80 and older (reflecting a relatively low level of achievement). To track progress in Daily Training, the participants maintained a Personal Data File within the program under the careful guidance of the author or a research assistant. Once familiar with Quick Play Mode and upon creating a Personal Data File in Daily Training, participants played through all the available games offered to them via Training Mode.

As participants progressed through Daily Training, more mini-games became available to them. Participants played all of the available mini-games, up to nine by the time they reached the 15th and final session. In each session, participants completed the Daily Training portion of the game and then proceeded to complete the Brain Age Check, which is comprised of three mini-games not otherwise found in Daily Training. Lastly, once participants completed Brain Age Check, they proceeded to play Sudoku for at least 15 minutes. While challenging for a novice player, most players experienced a sharp learning curve and were able to play the puzzle game after just a few sessions. Brain Age has players complete relatively easy Sudoku puzzles at first; however, after many sessions, participants were given the option to complete more difficult puzzles. As noted, participants followed this protocol for the duration of one hour per game playing session, with an occasional break when necessary.

In summary, the protocol was as follows: participants assigned to the treatment condition (a) first became familiar with the basic operations of the handheld game device (e.g., turning it off/on and navigating menus) and with the training programs offered in Quick Play Mode; (b) created a Personal Date File and began playing Daily Training Mode; (c) played through the three mini-games in Brain Age Check; and (d) played Sudoku for at least 15 minutes. Once participants were familiar with Brain Age (usually by the end of the first training session), subsequent sessions consisted of parts (b) through (d). The author or research assistant kept track of the specific mini-games played by each participant and of the scores earned in each of the 15 training sessions. After completing 15 training sessions during the five week period, participants completed the post-test battery.

Training of Students/Research Assistants. Before being allowed to work with participants, would-be research assistants (all California State University Northridge undergraduate and graduate students) underwent four weeks of training. The training (provided by the author) was comprised of playing Brain Age for a total of 15-20 hours over the course of 2-3 weeks, which allowed research assistants to master various aspects of the Nintendo DS and the game (e.g., navigation and mini-game play). In addition, would-be research assistants practiced assessment sessions with the author, members of his research laboratory, and if possible, any familiar older adults (at least 5 hours). Would-be research assistants also studied research articles and book chapters on the topic of teaching computer-based and videogame technology to older adults (at least 4 hours). They were trained according to the interviewing and assessment principles outlined in Dillman (1999) and Fowler and Magione (1991), and they strictly followed the study's procedures and the intervention protocol.

3.4 *Analysis Strategy*

There are at least two possible ways of statistically testing the effect that the video game intervention has on the outcome variables. One possibility is to conduct a t-test comparison between groups on the basis of their gain scores (as done in Study 1). This approach has long been criticized for generating biased findings stemming from the unreliability of gains scores (see Cronbach & Furby, 1970; Lord, 1956; Lord & Novick, 1968). However, as discussed in more recent work (Dimitrov & Rumrill, 2003; Rogosa, Brandt, & Zimowski, 1982; Zimmerman & Williams, 1996), the extent to which gain scores are unreliable is dependent upon not just the correlation between pre and post-test scores (larger correlations yield lower reliabilities of the difference scores), but also on the ratio of the pre-test and post-test standard deviations. Specifically, the unreliability of gain scores is apparent only in situations in which the reliabilities of the pre and post-test scores are identical, the correlation between pre and post-test scores is high ($r > .60$), and when the ratio of the pre-test and post-test standard deviations is equal to 1.0 (that is, they are identical). In fact, Zimmerman and Williams (1996) show that even in cases with pre-post correlations of .80, the corresponding gain scores are highly reliable when the ratio of pre-post standard deviations declines from 1 to .50 or .25.

It appears that Cronbach and others limited their critique of change scores to the precise situation in which the ratio of the pre and post-test standard deviations is exactly 1 and the reliabilities of pre and post-test scores are identical. Yet, it is possible that, particularly in applied testing settings, an intervention may have an impact on not just the post-test mean but also the post-test standard deviation (Rogosa, Brandt, & Zimowski, 1982; Zimmerman & Williams, 1996). Thus, while Cronbach and others are correct in questioning the reliability of gain scores, their concerns are limited to narrow circumstances that do not appear to generalize to practical experimental situations.

Another possible approach by which to examine the impact of the intervention is via an analysis of covariance (ANCOVA) and/or multivariate analysis of covariance (MANCOVA). ANCOVA allows the comparison between group means after adjusting for one or more variables (i.e., covariates) purported to be highly related with the outcome variable (Tabachnick & Fidell, 2001; Warner, 2008). In the case of the t-test, difference scores are created based upon the pre and post-test data before commencing with analyses. On the other hand, ANCOVA handles such data by examining mean differences on the post-test after statistically controlling for pre-test performance. Like a t-test, ANCOVA allows for the examination of mean differences; however, ANCOVA accomplishes this by first statistically adjusting group means on the basis of one or more covariates. Thus, while t-tests on gain scores allow one to examine whether the average gain is larger in one group over the other, ANCOVA allows one to examine whether there is a mean difference between groups on post-test scores after adjusting for differences in pre-test scores and/or other covariates.

If the assumptions of ANCOVA are met (discussed below) and the proposed covariate is strongly associated with the outcome variable in question, ANCOVA offers greater statistical power (Breukelen, 2006; Tabachnick & Fidell, 2001). ANCOVA increases statistical power by removing error variances (i.e., variance not associated with the grouping variable) that can be accounted for by the covariate(s); this reduction in the post-test residual variance results in greater statistical precision (Jamieson, 2004). Given the increase in statistical power, fewer participants are needed to generate standard errors equal to what one would obtain using t-tests on gain scores with a larger number of participants (Breukelen, 2006). The statistical power advantage offered by ANCOVA, in addition to its ability to examine the effect of multiple covariates, made it the most appropriate approach for analyzing data stemming from the current study. However, as mentioned above, there are many assumptions associated with proper use of ANCOVA (Miller & Chapman, 2001; Warner, 2008):

1. The covariate and the outcome variables should demonstrate relatively normal distributions.
2. The relationships between the covariate and the outcome variable should be approximately linear with homogeneity of variance on the outcome variable across the groups under comparison.
3. The relationship between the covariate and the outcome variable is identical for all groups under comparison.
4. The covariate is not associated with group assignment.

This final assumption is one that is central to the controversy surrounding the use of ANCOVA (Colliver & Markwell, 2006; Jamieson, 2004; Miller & Chapman, 2001; Suckling, 2010). At the core of this controversy is the use of ANCOVA in studies not employing random assignment. The consensus in the literature is against the use of ANCOVA with non-equivalent groups because of the possibility of the confounding between the covariate and grouping variable, rendering the adjusted group means largely uninterpretable (Huitema, 1980;

Miller & Chapman, 2001; Suckling 2010). The goal of ANCOVA is only to remove variance from the outcome variable, which in a study employing random assignment, is simply noise. On the other hand, when the covariate is correlated with the grouping variable (as in non-equivalent group studies), the ANCOVA will lead to the removal of variance in the grouping variable that may otherwise be shared with the outcome variable, obscuring the part of the treatment effect (Miller & Chapman, 2001). Employing ANCOVA with non-equivalent groups can also lead to spurious findings in cases where the covariate is highly correlated with the grouping variable but the grouping variable is poorly correlated with the outcome variable; in such cases, the covariate will remove variance in both the grouping variable and the outcome variable, artificially increasing the proportion of variance the grouping variable and the outcome variable end up sharing (Miller & Chapman, 2001). Thus, while some do not outright dismiss the use ANCOVA with non-equivalent group studies[4] (see Colliver & Markwell, 2006), the consensus among most sources is to use ANCOVA only with true experimental designs employing random assignment (Cochran, 1957; Elashoff, 1969; Huitema, 1980; Miller & Chapman, 2001; Suckling 2010). Pending examination of the additional assumptions, ANCOVA was selected as an appropriate analytical approach for the present study.

In an effort to obtain preliminary evidence concerning the study hypotheses, a MANCOVA analysis was conducted. Like ANCOVA, MANCOVA

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[4] See Colliver & Markwell (2006) for a discussion on using effect size indices to estimate the selection bias resulting from the use of non-equivalent group designs.

examines group differences after adjusting for one or more covariates. However, unlike ANCOVA, it examines group differences among multiple simultaneously included outcome variables (Giles, 2002; Tabachnick & Fidell, 2001). Therefore, rather than conducting a separate ANCOVA for each outcome variable, MANCOVA allows one to explore group differences on a combination of dependent variables after controlling for (potentially) a combination of covariates. One advantage of MANCOVA over ANCOVA is in reducing the Type I error rate resulting from conducting multiple significance tests; another is that it allows one to identify the variable on which groups maximally differ after adjusting for a host of covariates that may collectively account for a significant amount of the noise among many outcome variables. From this standpoint, MANCOVA offers one a good starting point in regards to gleaning an overall intervention effect. To further elucidate any potential group obtained via MANCOVA effect, subsequent univariate tests were planned in order to isolate the unique effect that the intervention had in individual outcome measures while adjusting for the collective set of covariates.

An alternative to further exploring MANCOVA findings via univariate tests is the Roy-Bargmann Stepdown Analysis (Bock & Haggard, 1968; Tabachnick & Fidell, 2001). The primary benefit of the Stepdown Analysis is the increased control it offers one over the inflation of the Type 1 error. The Stepdown Analysis accomplishes this by requiring one to prioritize the outcome measures on the basis of theoretical or practical considerations. The highest priority outcome measure is then examined via ANCOVA first while adjusting on all covariates; a second ANCOVA is then conducted on the second highest priority outcome variable while adjusting for the covariates and the first outcome measure (i.e., the highest priority DV). This hierarchical process of adjusting for all previously examined DVs and covariates continues until a given model no longer indicates significant group differences after adjusting for all previously identified DVs and covariates. Thus, if only the first analysis uncovers significant group differences, then the analyst is left to conclude that groups only differ meaningfully on the basis of the first DV that was examined (see Bock & Haggard, 1968 or Tabachnick & Fidell, 2001 for a technical discussion). While more rigorous in its control over the inflation of alpha, the Stepdown Analysis requires that the analyst have a priori ideas about which specific outcome variables are most meaningful to examine (prioritizing DVs on the basis of univariate tests serves to capitalize on chance, undermining one's goal to control alpha). In the current study, however, predictions were not made about which specific DVs were most theoretically or practically meaningful (hypotheses about the transferability of effects or the effect of timed measures encompass more than one outcome variable). Thus, all univariate tests were planned as follow-up analyses for the MANCOVA, and intended to control the inflation of alpha in all univariate tests via the Šidàk-Bonferonni Correction (Abdi, 2007):

$$\alpha' = 1 - (1 - \alpha)^{1/n}$$

where α represents the family wise alpha level (i.e., $\alpha = .05$), n represents the number of total independent comparisons, and α' represents the adjusted alpha level for each test. Given the 16 planned comparisons (cognitive and affective/attitudinal outcomes), the resulting alpha per test was set to .0032.

Rationale for Covariates. As discussed earlier, the increased statistical power offered by ANCOVA (and MANCOVA) make them the preferred approaches for examining the effects of the intervention, particularly since participants in Study 2 were randomly assigned to conditions. Given the pre- and post-test data gathered for all outcome variables of interest, ANCOVA analyses reported herein utilized corresponding pre-test scores as covariates for each outcome variable. In addition, however, analyses examining differences along cognitive outcomes included the MAT as an additional covariate. The MAT is highly related to the Mini Mental Status Examination (MMSE), which measures an array of cognitive abilities, including attention and concentration, language, and spatial functioning (Rami et al., 2007; Rami et al., 2009). Based upon this relationship, it stands to reason that performance on the MAT would be associated with performance on several, if not all, cognitive outcome measures utilized in the present study. Including MAT performance in ANCOVA analyses involving cognitive outcomes is thus expected to further enhance the statistical power associated with group comparisons. Given the lack of evidence tying MAT performance to affective or personality measures, the MAT was not used as an additional covariate in analyses involving affective or attitudinal outcome measures. Further bolstering this approach are findings from Study 1 indicating that the MAT was significantly associated with performance on both the Trail Making Task A (r = -.47, p = .007) and Task B (r = -37, p = .04), but not significantly associated with feelings of control ($r = .10$, $p = .58$). Given the varying number of covariates used with either cognitive and affective/personality outcomes, we planned to conduct two separate MANCOVAs – one for cognitive outcomes that include the cognitive pre-test scores and MAT scores, and a second one for the affective outcomes that only include affective/attitudinal pre-scores as covariates. As expected in light of the random assignment to conditions, preliminary analyses did not indicate a significant difference between the treatment ($M = 43.8$, $SD = 3.49$) and control ($M = 44.93$, $SD = 3.70$) groups with respect to MAT performance, $t(33) = .97$, $p = .34$.

To summarize, ANCOVA (and MANCOVA) offer researchers employing random assignment to conditions a more statistically powerful alternative to gain score analysis. We focused our initial analyses on findings stemming from the aforementioned MANCOVAs to explore group differences across the collective set of outcome variables while employing the collective set of pre-test scores (and MAT scores for the MANCOVA on cognitive outcomes). Subsequent univariate analyses were planned to further elucidate a possible group effect by examining group differences by each outcome variable while employing all pre-test scores (and MAT scores, if applicable) as covariates. Lastly, to isolate the relationship between each DV, its corresponding covariate(s), and the grouping variable, we intended to conduct subsequent ANCOVAs for each DV while only using a corresponding pre-test score (and in the case of cognitive outcomes, the MAT score) for each analyses.

3.5 *Results*

Data Screening and Testing for Assumptions. Before beginning any analyses, all variables – both outcome variables and covariates – were first examined for violations of normality. Screening for such violations entailed visually examining the distributions via stem-leaf displays, observing the highest and lowest scores on each variable in relation to the rest of the corresponding distribution, and identifying both skewness and kurtosis statistics for each variable. Such examination uncovered potential outliers across multiple variables. Rather than eliminating such data from analyses, they were Winsorized by recoding each value to a more moderate value, specifically the second most extreme value in the corresponding tail of the distribution. All findings reported hereafter are based upon these Winsorized values, which when observed by virtue of the aforementioned criteria, were found to be reasonably normal. Additionally, given that platykurtosis (or excessively flattened distribution of scores) substantially reduces statistical power (Glass, Peckham, & Sanders, 1972), checks for platykurtosis were conducted by dividing the kurtosis value of each variable by its corresponding standard error to look for any resulting values greater than 2 or less than -2 (see Giles, 2002). Analysis of the Winsorized variables did not uncover issues indicative of platykurtosis. Lastly, scatterplots between each outcome variable and its corresponding covariate(s) indicated linear relationships with no extreme bivariate outliers.

As part of each univariate analysis, the author examined the homogeneity of variance across groups for each outcome variable in question (i.e., Levene’s

Test). In the case of MANCOVA, Box's M Test was examined to identify potential group differences on the basis of their variance-covariance matrices. Such examination did not uncover violations for either set of analyses. In addition, non-significant correlations ($p > .10$) were found between each of the covariates and the grouping variable, and there was no significant group difference on any covariate/pre-test variable. Lastly, findings did not point to a significant interaction effect between any covariate and the grouping variable in predicting post-test performance on all outcome variables, thus indicating homogeneity of regression across groups for all outcome variables.

Demographic Variables. Table 3.1 illustrates the demographic information for each group. Since participants were randomly assigned to conditions, there was no basis upon which to expect the groups to differ significantly on any demographic characteristics. However, before commencing with the primary analyses, preliminary inferential tests were conducted to further assess the equivalence of the groups in question. Analyses did not reveal a significant difference between groups with regards to the following characteristics[5]:

- Gender ($\phi = .15$, $p = .37$).
- Educational background ($t = .052$, $p = .96$) or income ($t = 1.26$, $p = .21$).
- The likelihood of owning a video game ($\phi = .09$, $p = .61$).
- The likelihood of playing a video or computer game ($\phi = .10$, $p = .64$).

[5] Ethnic background was not compared between groups as 32 of 35 participants identified themselves as Caucasian.

- The likelihood of attempting or completing any type of puzzles, such as crossword puzzles (ϕ = .07, p = .76).

Table 3.1

Demographic Characteristics Among Participants in Study 2 (N = 35)

Characteristic	Treatment		Control	
	N	%	N	%
Gender				
Male	4	20	5	33
Female	16	80	10	67
Education				
Less than high school	0	0	2	13
High School Graduate	3	15	1	7
Completed Trade School	2	10	1	7
Some College	9	45	6	40
Bachelor's Degree	1	5	1	7
Some Grad School	2	10	1	7
Master's Degree	3	15	3	20
PhD/MD/JD	0	0	0	0
Annual Income				
Less than $20k	6	30	3	20
$20 - $39k	7	35	2	13
$40 - $59k	2	10	2	13
$60 - $79k	2	10	4	27
$80 - $99k	0	0	1	7
$100 or greater	2	10	1	7
No Response	1	5	2	13
Game Ownership				
No	16	80	13	87
Yes	4	20	2	13
Frequency of Game Play[1]				
Less than once per month	6	50	4	40
More than once per month	6	50	6	60
Puzzle Completion[1]				
No	6	50	4	57
Yes	6	50	3	43

[1] Items asking participants about frequency of game play and puzzle completion were included into the assessment protocols after commencing the implementation of Study 2, meaning that some individuals partaking in the study during the first semester of implementation did not encounter these items

Additional preliminary analyses did not uncover a statistically significant difference age between the treatment (*M* = 74.95, *SD* = 6.53) and the control groups (*M* = 74.40, *SD* = 5.62; *t*(33) = .26, *p* = .80). Group differences were explored with respect to the total number of physical or exercise-related activities completed over the last three months; however, no significant difference was found between the treatment (*M* = 2.40, *SD* = 1.87) and the control group (*M* = 3.33, *SD* = 1.40; *t*(33) = 1.62, *p* = .12). Lastly, analyses did not indicate a significant difference between the treatment (*M* = 92.97, *SD* = 6.28) and control group (*M* = 93.96, *SD* = 4.36) on the basis of their VFQ scores, *t*(17) = .40, *p* = .70.

*MANCOVA and Univariate Test*s. A MANCOVA was first conducted on all of the 13 cognitive outcome variables (including the number of errors stemming from the arithmetic and syllable count measures). Due to listwise deletion of cases with missing data, only 32 of the 35 cases (17 treatment; 15 control) were included in these analyses. The covariates included all pre-test scores for the same 13 outcome variables along with the MAT scores. A check of assumptions did not uncover any violations of homogeneity of variance-covariance matrices (i.e., Box's M), homogeneity of variance between the groups under comparison (i.e., Levene's Test), normality, or linearity. With the use of Hoteling's Trace as the criterion, the grouping variable had a significant effect on the combined DVs, *F*(13, 4) = 6.57, *p* = .04. Moreover, the finding that $\eta^2 = .96$

indicates that, after adjusting for the collective set of covariates, the intervention had a large impact on the combined cognitive outcomes.

Table 3.2 illustrates findings stemming from univariate analyses examining the effect of the grouping variable on each cognitive outcome after adjusting for the collective set of pre-test and MAT scores. Based upon the Bonferroni adjusted test alpha ($\alpha = .003$), no difference attained statistical significance. However, findings do indicate a marginally significant effect for time to complete the Mini Syllable Assessment, $F(1,30) = 11.50$, $p = .004$. The corresponding eta squared ($\eta^2 = .42$) indicates a moderate to large effect. Examination of the estimated marginal means indicates that the treatment group (*Msec* = 75.67, *SD* = 23.19) spent less time completing the task than the control group (*Msec* = 106.08, *SD* = 23.45). The effect size *d* of 1.30 further illustrates a robust finding, indicating that the average participant in the treatment group spent less time completing the task than did 90% of participants in the control group. A second marginally significant effect was found in regards to the Stroop Inference Task (i.e., Stroop Task 3), $F(1,30) = 7.33$, $p = .016$. With an eta squared value of .31, findings point to a moderate effect. The estimated marginal means indicate that the treatment group (*Msec* = 58.09, *SD* = 17.00) spent less time completing the task than did the control group (*Msec* = 75.88, *SD* = 17.20). The corresponding effect size *d* of 1.04 indicates that the average treatment group participant spent less time completing the task than 85% of control group participants.

Table 3.2

Univariate Findings for all Cognitive Outcomes Stemming from the Inclusion of the Collective Set of Pre-Test Scores and MAT Scores

Outcome Variable	Univariate *F* (*df = 1, 16)*	*p*
Syllable (Time)	11.50	.004
Stroop (Interference)	7.33	.016
Arithmetic (Time)	2.12	.17
Stroop (Color Patch)	1.33	.27
Trail Making B	.88	.36
Arithmetic (Errors)	.87	.36
Trail Making A	.77	.39
Syllable (Errors)	.73	.41
Card Sorting 2	.50	.49
Card Sorting 1	.50	.49
Stroop (Word Reading)	.11	.75
Raven's Matrices	.09	.77
Card Sorting 3	.003	.96

Sidak-Bonferroni Test $\alpha = .0032$

A second MANCOVA was conducted on the three personality/attitudinal outcomes. The covariates included each of the corresponding pre-test scores, and findings are based upon 28 cases (15 treatment; 13 control). As in the case of the cognitive outcomes, an examination of assumptions did not indicate any violation of homogeneity of variance-covariance matrices (i.e., Box's M), homogeneity of variance between groups (i.e., Levene's Test), normality, or linearity. Based upon Hoteling's Trace, findings did indicate a significant group effect on the combination of DVs, $F(3,21) = .64$, $p = .60$. As illustrated in Table 3.3, univariate findings did not indicate any significant effects.

Table 3.3

Univariate Findings for all Affective/Attitudinal Outcomes Stemming from the Inclusion of the Collective Set of Pre-Test Scores

Outcome Variable	Univariate F ($df = 1, 23$)	p
Control	1.26	.27
Self-Esteem	.85	.37
Video Games Attitudes	.20	.66

Sidak-Bonferroni Test $\alpha = .0032$

Conclusions Stemming from MANCOVA and univariate analyses. These initial findings indicate group differences with regards to timed cognitive measures that were directly practiced via the game intervention, and they offer preliminary evidence consistent with the hypothesis that the intervention would have a more robust impact on cognitive outcomes than on affective/attitudinal outcomes. While supporting the stated hypotheses, the univariate findings explored group difference by individual outcome variable after adjusting for the collective set of covariates. Assuming that pre-test scores are uniquely correlated with the outcome measure in question, then this approach serves to enhance statistical power. However, as illustrated in Table 3.2, such an approach may actually serve to reduce statistical power inasmuch as it results in a substantial loss in degrees of freedom (one for each covariate). The table in Appendix A, for instance, illustrates the zero-order correlations between each covariate (i.e., pre-tests and MAT) and each of the post-test variables. It displays that the post-test scores on the Mini Syllable Count Assessment (i.e., SCT) are not only highly associated with corresponding pre-test scores (r = .73), but also with pre-test scores on the Trail Making Task A (i.e., TA; r = .52). The partial correlation between pre-test SCT scores and post-test SCT scores, after accounting for pre-test TA scores, is still high (r = .63). This means that a greater proportion of the error variance in the SCT post-test scores was accounted for by the covariates, increasing the precision of the comparison and resulting in greater statistical power.

Given the correlations between the post-test Stoop Interference Test (i.e., STI) scores and all the Stroop pre-test scores (Appendix A), the same argument can be made of the robust group difference obtained for the Stroop Interference Test. While informative, a univariate test that includes as many covariates as the present study employs is not a parsimonious statistical model; in addition, given the small number of degrees of freedom remaining in the error term, it may be a statistically powerful approach only in cases where, like the post-test SCT and STI scores, more than one covariate is strongly associated with the DV in question. Another issue has to do with the generalizability of findings stemming from the use of so many covariates; findings stemming from this approach may not be easily replicable given that subsequent work would have employ all of the current study's measures in order to replicate the specific group comparisons reported herein. Thus, these univariate findings not only fail to answer the question of whether group differences exist after accounting for only corresponding pre-test scores, but they also reflect the employment of a model that may not be easily reproduced by other researchers. For these reasons it is useful to consider ANCOVA analyses that use only corresponding pre-test scores (and in the case of cognitive outcomes, the theoretically relevant MAT scores) as covariates.

The table in Appendix B provides the correlations between the pre-test scores on the affective/attitudinal measures and corresponding post-test scores. The largest correlations (all significant at .01 level) are between the pre and post-test scores of the same construct (e.g., $r = .86$ for Control). However, a significant correlation was also found between the pre-test control scores and post-test esteem scores ($r = .45$, $p = .02$). Given the rather limited number of affective/attitudinal variables, there does not appear to be the same problems relating to statistical power and parsimony that are apparent with univariate analyses of cognitive variables.

ANCOVA Findings. ANCOVAs were conducted on each of the 16 outcome variables after adjusting for corresponding pre-test scores (also the MAT scores for cognitive outcomes). Tables 3.4 and 3.5 display findings for each of the 13 cognitive outcomes variables. While Table 3.4 displays significance test findings, Table 3.5 displays the adjusted cognitive outcomes means, along with corresponding effect size *d*s and 95% confidence intervals.

Table 3.4

ANCOVAs Examining the Effect of the Grouping Variable on Each of the Cognitive Outcomes After Adjusting for Corresponding Pre-Test Scores and MAT Scores

Outcome Variable	Univariate *F*	df	*p*
Syllable (Time)	13.96	1/31	.001*
Arithmetic (Time)	10.09	1/31	.003*
Stroop (Interference)	6.60	1/30	.02
Arithmetic (Errors)	2.98	1/31	.09
Syllable (Errors)	.70	1/31	.41
Card Sorting 3	.33	1/31	.57
Stroop (Color Patch)	.28	1/31	.60
Raven’s Matrices	.28	1/30	.60
Stroop (Word Reading)	.24	1/31	.63
Card Sorting 1	.22	1/31	.64
Trail Making B	.18	1/30	.67
Trail Making A	.11	1/31	.75
Card Sorting 2	.08	1/31	.73

Sidak-Bonferroni test $\alpha = .0032$

* $p < .0032$

Table 3.5

The Adjusted Means, Standard Deviations and Effect Size ds for each of the Cognitive Outcomes Stemming from ANCOVA Analyses (N = 34-35)

	Intervention Group		Control Mean (SD)			
	Mean	SD	Mean	SD	*d*	95% CI (*d*)
Syllable (Time)*	76.96	21.17	104.24	21.22	1.28	.55 to 2.02
Arithmetic (Time)*	35.49	6.35	42.50	6.38	1.10	.38 to 1.82
Stroop (Interference)	57.09	19.55	74.58	19.59	.89	.18 to 1.60
Arithmetic (Errors)	.71	1.03	1.32	1.03	.59	-.09 to 1.28
Syllable (Errors)	1.44	1.05	1.75	1.05	.29	-.38 to .97
Card Sorting 3	89.37	21.83	93.71	21.87	.20	-.47 to .87
Stroop (Color Patch)	30.54	4.15	31.33	4.17	.19	-.49 to .87
Raven's Matrices	6.05	1.60	6.34	1.60	-.18	-85 to .49
Stroop (Word Read)	23.36	2.85	23.84	2.87	.17	-.50 to .84
Card Sorting 1	38.63	5.55	37.73	5.57	-.16	-.83 to .51
Trail Making B	79.69	16.72	82.20	16.20	.15	-.54 to .84
Trail Making A	36.18	9.03	37.21	9.09	.11	-.56 to .78
Card Sorting 2	59.83	10.04	58.86	10.06	-.10	-.77 to .58

Sidak-Bonferroni test $\alpha = .0032$
* $p < .0032$

There was a significant group difference with respect to Mini Syllable Assessment ($F(1, 31) = 13.96$, $p = .001$), as the treatment group (*Msec* = 76.96, *SD* = 21.17) completed the assessment more quickly than the control group (*Msec* = 104.24, *SD* = 21.22). The corresponding effect size *d* (1.28) indicates that the average treatment group participant completed the task more quickly than 90% of individuals in the control group. Meanwhile, the treatment group (*Msec* = 35.49, *SD* = 6.35) also completed the Mini Arithmetic Assessment significantly more quickly than the control group (*Msec* = 42.50, *SD* = 6.38), *F* (1,31) = 10.09, *p* = .003. An effect size *d* of 1.10 indicates that the average participant in the treatment group was quicker to complete the task than 86% of participants in the control group. Lastly, a marginally significant difference was obtained on the Stroop Interference Test (*F*(1,30) = 6.60, *p* = .02) as the treatment group (Msec = 57.09, SD = 19.55) again completed the task more quickly than the control group (*Msec* = 74.58, *SD* = 19.59). The corresponding effect size *d* (.89) indicates that the average treatment group participant was more quick to complete the assessment than 82% of control group participants.

Positive effect size *d*s are indicative of a treatment group advantage over the control group. Therefore, with the exception of the Raven's Matrices, lower means among the treatment group would reflect quicker task completion (e.g., Mini Syllable Assessment, Card Sorting Tasks) or lower error rates (e.g., Mini Syllable Assessment Errors, Mini Arithmetic Assessment Errors). With respect to the Raven's Matrices, the outcome measure was the total number of correct responses; as such, the lower mean score reported for the treatment group (M_{adjust} = 6.05, *SD* = 1.60 – Treatment; $M_{adjust =}$ 6.34, *SD* = 1.60 – Control) is indicative of a control group advantage over the treatment group, resulting in a nonsignificant negative effect size value (d_{adjust} = -.18).

Findings specific to the Mini Syllable Assessment and the Mini Arithmetic Assessment indicate robust group differences on the basis of the adjusted means (*d*s_{adjust} = 1.28 & 1.10, respectively). In fact, the lower bound of the 95%

confidence interval for the Mini Syllable and Mini Arithmetic Assessments (.55 & .38, respectively) further suggests a large effect among each outcome. Another potentially meaningful effect is with respect to the Stroop Interference Test (d_{adjust} = .89), indicating that the average Stroop Interference Test time generated by the treatment group was lower than that of 82% of times generated by the control group. Lastly, a potentially meaningful group difference was found with regards to the number of errors committed on the Mini Arithmetic Assessment d_{adjust} = .59), indicating that the average number of errors committed by the intervention group was fewer than 73% errors committed by control group participants.

Table 3.6 displays the correlations between all post-test cognitive variables. As one might expect, the Card Sorting Tasks (i.e., CS1, CS2, and CS3) were highly associated with each other, as were the Stroop Tests (i.e., STC, STW, and STI). Noteworthy, however, is the high correlation identified between the Mini Arithmetic Assessment (MAA) and several other cognitive measures. The MAA was found to be highly associated with both Trail Making Tasks (r = .54 for TA; r = .62 for TB), the Mini Syllable Assessment (MSA; r = .46), and two of the three Stroop Tests (r = .53 for Color Patch; r = .54 for Word Reading).

Table 3.6

Correlation Matrix Among Cognitive Post-Test Variables (N = 34-35)

	TA	TB	RAV	ART	ARE	SCT	SCE	CS1	CS2	CS3	STC	STW	STI
TA	1												
TB	.52*	1											
RAV	-.42	-.43	1										
ART	.54*	.62**	-.31	1									
ARE	.06	.27	-.30	.35	1								
SCT	.36	.28	.03	.46*	.15	1							
SCE	.22	.18	-.42	.27	.46*	.14	1						
CS1	.47*	.41	-.40	.40	.01	.14	.07	1					
CS2	.32	.39	-.40	.20	.10	.15	-.02	.76**	1				
CS3	.44*	.47*	-.24	.28	.11	.35	.21	.50*	.58**	1			
STC	.23	.40	-.31	.53*	.36	.26	.38	.29	.32	.27	1		
STW	.33	.36	-.14	.54*	.25	.40	.29	.07	.21	.28	.81**	1	
STI	.53*	.51	-.42	.43	.28	.36	.26	.34	.33	.15	.49*	.53*	1

TA = Trail Making A
TB = Trail Making B
RAV = Raven's Matrices
ART = Mini-Arithmetic (Time)
ARE = Mini-Arithmetic (Errors)
SCT = Mini Syllable (Time)
SCE = Mini Syllable (Errors)
CS1 = Card Sorting Task 1
CS2 = Card Sorting Task 2
CS3 = Card Sorting Task 3
STC = Stroop Test (Color Patch)
STW = Stroop Test (Word Read)
STI = Stroop Test (Interference)

** $p < .01$
* $p < .05$

Tables 3.7 and 3.8 display findings stemming from ANCOVAs conducted on the affective/attitudinal outcomes after adjusting for corresponding pre-test scores. No significant group differences were identified. As indicated in Table 3.8, each of the adjusted group means points to a treatment group advantage; however, all effect size *d*s are small in magnitude.

Table 3.9 shows the correlations between each of the three affective/attitudinal variables. Despite the fact that video game attitudes were not found to be associated with either feelings of control or self-esteem, a strong correlation was found between feelings of control and self-esteem (r = .52, p = .003).

Table 3.7

ANCOVAs Examining the Effect of the Grouping Variable on Each of the Affective Outcomes After Adjusting for Corresponding Pre-Test Scores

Outcome Variable	Univariate *F*	df	*p*
Control	.54	1, 26	.47
Video Game Attitudes	.42	1, 30	.52
Self-Esteem	.02	1, 32	.90

Sidak-Bonferroni test α = .0032

Table 3.8

The Adjusted Means, Standard Deviations and Effect Size ds for each of the Affective/Attitudinal Outcomes Stemming from ANCOVA Analyses (N = 29 – 35)

	Intervention Group		Control Group			
	Mean	SD	Mean	SD	*d*	95% CI (*d*)
Control	12.99	1.03	12.71	1.03	.27	-.46 to 1.00
Video Game Attitudes	18.05	3.07	17.35	3.07	.23	-.46 to .92
Self-Esteem	35.92	3.11	35.78	3.12	.04	-.62 to .71

Sidak-Bonferroni test α = .0032

Table 3.9

Correlation Matrix Among Affective/Attitudinal Post-Test Variables (N = 29 – 35)

	Control	Esteem	Attitudes
Control	1		
Esteem	.52**	1	
Attitudes	-.09	-.10	1

** $p < .01$
* $p < .05$

Examining the Impact on Practiced and Timed Cognitive Variables, and on Cognitive versus Affective Variables. In addition to examining the impact of the current study's impact on cognitive and affective variables, the focus was also on evaluating three key hypotheses, namely that the study findings would yield larger effects for (a) practiced over non-practiced cognitive measures, (b) timed versus non-timed cognitive measures, and (c) cognitive over affective/attitudinal variables. To that end, adjusted effect size *d*s were grouped according to the stated hypotheses and resulting average mean effects were examined.

Figure 3.1 illustrates the comparison of practiced versus non-practiced tasks. In support of the stated hypothesis, an apparently robust difference exists between groups. In fact, the average effect size *d* for practiced effects (d_{adjust} = .63, *SD* = .47) was greater in magnitude than the largest effect obtained for the non-practiced effects (d_{adjust} = .20, *SD* = .18). Figure 3.2 illustrates the mean effects for timed and non-timed cognitive assessments. While timed measures collectively yield larger effects (d_{adjust} = .38, *SD* = .51) than non-timed measures (d_{adjust} = .23, *SD* = .39), the difference appears far less robust than that found for practiced variables. Figure 3.3 displays the mean effect size *d*s for the collective set of cognitive variables (d_{adjust} = .35, *SD* = .49) and the set of affective/attitudinal variables (d_{adjust} = .18, *SD* = .23). While supportive of the stated hypothesis, findings seem to point to only a small to moderate difference between cognitive and affective variables.

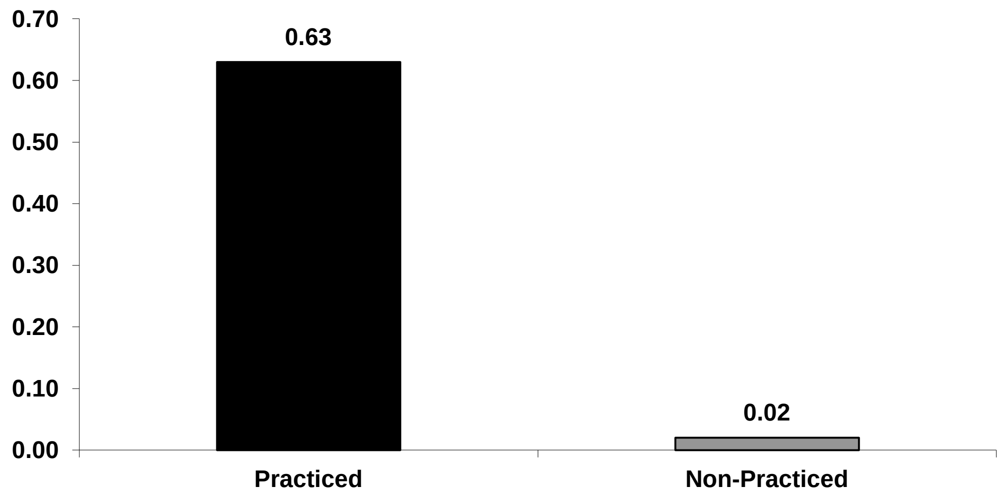

Figure 3.1. Comparison of the Mean Effect Size *d*s on the Basis of Practiced (N = 7) and Non-Practiced (N = 6) Cognitive Outcomes.

Note. Findings reflect adjustment for corresponding pre-test and MAT scores. Practiced variables included the following: Trail Making Tasks A and B, the Mini Arithmetic Assessment (both the timed and error assessments), the Mini Syllable Assessment (both the timed and error assessments), and the Stroop Interference Test. Non-Practiced variables included the following: the Card Sorting Tasks (CS1-CS3), the Stroop Color Patch and Word Reading assessments, and the Raven's Matrices assessment.

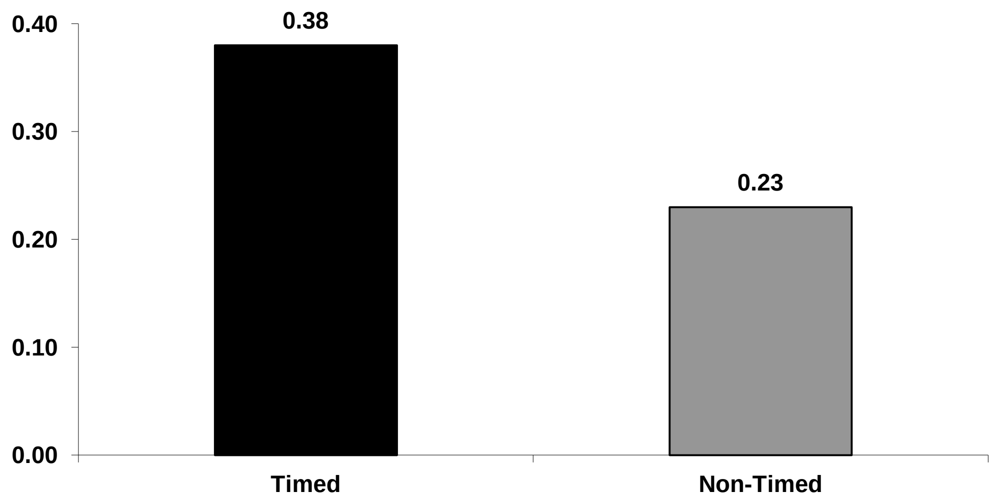

Figure 3.2. Comparison of the Mean Effect Size *d*s on the Basis of Timed (N = 10) and Non-Timed (N = 3) Cognitive Outcomes.

Note. Findings reflect adjustment for corresponding pre-test and MAT scores. Timed cognitive variables included the following: Trail Making Tasks A and B, the Mini Arithmetic Assessment (only the timed assessment), the Mini Syllable Assessment (only the timed assessment), all the Stroop Tests, and all the Card Sorting Tasks (CS1-CS3). Non-Timed variables included the following: the Mini Arithmetic Assessment (number of errors), the Mini Syllable Assessment (number of errors), and the Raven's Matrices assessment.

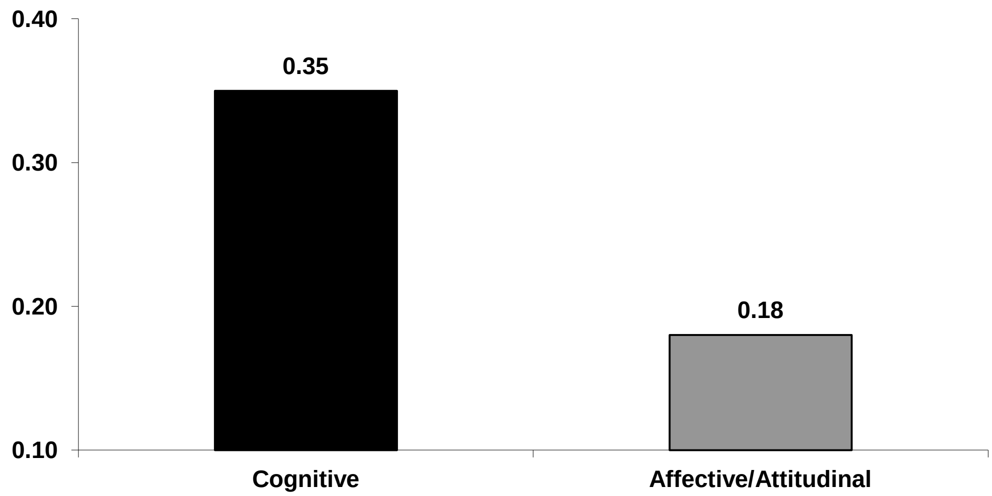

Figure 3.3. Comparison of the Mean Effect Size *d*s on the Basis of Cognitive (N = 13) and Affective/Attitudinal Outcomes (N = 3).

Note. Findings reflect adjustment for corresponding pre-test and MAT scores (only cognitive outcomes).

Principal Component Analysis of Post-Test Cognitive Outcomes. To enhance the conceptual clarity of the relationships that exist among the various cognitive outcomes, a principal component analysis (PCA) was conducted using the correlations displayed in Table 3.6. The clustering of variables that may be observed via PCA may point to overarching cognitive constructs that help further clarify the underlying communality among the cognitive variables for which the most robust effects have been observed.

Table 3.10 reflects the structure matrix loadings stemming from a PCA analysis with oblimin rotation (oblimin rotation was chosen due to the likely correlation among the underlying components). On the basis of a Scree Plot, a three-factor solution was identified.

Table 3.10

Structure Matrix Loadings Stemming from a Principal Components Analysis for a Three-Factor Solution with Oblimin Rotation (N = 34)

Cognitive Outcome	Component 1 Minimal Motor Function	Component 2 Extensive Motor Function	Component 3 Cognitive Reasoning
Stroop Test - Word Reading	-.85		
Mini-Arithmetic (Time)	-.75		
Mini-Syllable Count (Time)	-.73		
Stroop Test - Color Patch	-.71		
Stroop Test - Interference	-.62		
Card Sorting Task 1		-.88	
Card Sorting Task 2		-.85	
Card Sorting Task 3		-.71	
Trail Making A		-.66	
Trail Making B		-.64	
Mini-Syllable (Errors)			-.78
Mini-Arithmetic (Errors)			-.74
Raven's Matrices			.70

Note. Cross loadings on each component were all less than .55

There were strong loadings among the Stroop Tests (ranging from .62 to .85) along with the Mini-Arithmetic (.75) and Mini-Syllable Count (.73) Assessments. A cluster of variables, comprised of the Card Sorting and Trail Making Tasks (with Structure Matrix loadings ranging from .64 to .88), loaded strongly on a second component. Lastly, the non-timed outcomes (i.e., Mini-Arithmetic, Mini-Syllable, and Raven's Matrices) comprised a third cluster, with loadings ranging in magnitude from .70 to .78. The negative loadings for components one and two indicate that faster completion of the corresponding timed tasks reflects greater component scores; thus, larger component scores are indicative of greater cognitive performance. Likewise, the negative loadings for each error variable, coupled with the positive loading for the Raven's Matrices task, indicate that greater component three scores reflect greater cognitive performance. All cross-loadings among variables were below the .55 mark, indicating simple structure and facilitating interpretation.

Both sets of cognitive variables identified by the first two components are speed of processing measures designed to examine individuals' selective attention. However, the first set (i.e., Stroop Tests and Mini Assessments) differs from the second set (Card Sorting and Trail Making Tasks) in that the latter requires more extensive motor function and coordination to generate responses than does the former. Stacking cards into various piles on the basis of varying criteria and manually drawing lines connecting circles requires not just focused cognitive effort, but also extensive coordinated hand movements. This contrasts with the first set of outcome variables; although they too require focused cognitive effort, they do not simultaneously require extensive coordinated hand movements. The third component is comprised of non-timed measures that seemingly reflect general cognitive reasoning. Table 3.11 displays the component correlations. Given that all components reflect the measurement of cognitive functioning, it is not surprising to find moderate correlations between component one (i.e., Minimal Motor Function) and component two (i.e., Extensive Motor Function; r = .31), and between component one and component three (i.e., Cognitive Reasoning; $r = .27$). A positive correlation was also found between components three and two (*r* = .21), indicating that participants who completed the timed tasks more quickly tended to commit fewer errors.

Table 3.11

Component Correlation Matrix (N = 34)

Component	Minimal Motor	Extensive Motor	Cognitive Reasoning
Minimal Motor	1		
Extensive Motor	.31	1	
Cognitive Reasoning	.27	.21	1

Chapter 4: Discussion

4.1 *Summary of Findings and Implications*

The current study's intervention had a meaningful impact on several cognitive outcomes; findings indicated that participants playing Brain Age performed significantly better than did control participants with regards to a brief arithmetic task and a syllable counting task. Potentially meaningful differences were also found on the Stroop Interference test (requiring participants to say the color that color names are printed in rather than the words themselves). While only three outcomes achieved statistical significance, it should be noted that over 80% of obtained effects favored the treatment group; that is, 13 of the 16 of the outcomes investigated in the current study (i.e., based upon the adjusted mean differences) indicate an advantage in favor of those partaking in the intervention. Collectively, such findings support the idea that playing Brain Age in a structured manner over the course of five weeks has a beneficial impact on cognitive abilities and a potentially small positive effect on older adults' self-efficacy and self-esteem.

What the significant (and marginally significant) findings have in common is that they were all directly practiced within the context of the current study's video game intervention. Indeed, the intervention had a far larger impact on outcomes that were directly practiced in Brain Age than it did on outcomes not directly practiced. The Mini Arithmetic and the Mini Syllable assessments, along with the Stroop Interference Test, all yielded fairly robust effects (d = 1.28, *d* = 1.10, and *d* = .89, respectively). Such large effects point to the impact that a video game intervention can have on specific skills and abilities. While the benefits of playing a video game may be limited to the skills that are directly practiced, the practical benefits of acquiring those skills depends upon the extent to which they lend themselves to real-world application.

Many older adults may find that possessing sharpened arithmetic skills is meaningful to their everyday lives. Hence, to the extent that older individuals find such specific skills as practically meaningful to their everyday lives, games like Brain Age offer older adults an opportunity to enhance practically relevant skills. As mentioned earlier, the Stroop Tasks have been linked to activities of daily living (such as money management, medical administration, and meal planning and preparation) among healthy older adults (Cahn-Weiner, Malloy, Boyle, Marran, & Salloway, 2000). This means that Brain Age, and possibly games like it, have the potential of enhancing everyday functioning via two pathways. One of those pathways is by improving cognitive abilities that have been shown to be related to everyday functioning (e.g., Stroop Tests). Given the present findings, another viable pathway may be through offering regular practice with specific everyday tasks identified as relevant to enhancing the real-world functioning of older adults. Thus, while video games may enhance only directly practiced skills, the technology exists to design video games to teach specific real-world skills, like money management and meal planning. With the advent of smartphones and tablets like the iPad, video game applications can be designed to enhance these specific, yet meaningful, cognitive skills. While these are clearly issues that merit further study, the present study's findings point to the value of developing engaging video games designed to offer users regular practice with tasks that have clear real-world implications.

Findings also pointed to slightly larger effects among timed cognitive outcomes over non-timed outcomes. Brain Age offers users an array of mini-games, most of which keep track of how long participants take to complete a given game. After completion of these mini-games, users receive immediate feedback in the form of the actual time it took them to complete the game along with an overall performance assessment (e.g., a picture of a rocket to denote excellent performance, or bicycle to denote average performance). Indeed, given such feedback, coupled with the extensive practice they are already receiving, it is not surprising that timed outcomes yielded larger effects than non-timed outcomes. However, it should be noted that this comparison was comprised of only three non-timed outcomes (as opposed to 10 timed cognitive outcomes), two of which (number of errors committed in arithmetic and syllable count measures) were gathered by having participants complete timed tasks. Clearly, more work (preferably within the context of a meta-analysis) is needed to more closely examine the links between video games and timed (and non-timed) cognitive outcomes.

Findings stemming from a principal component analysis point to three possible constructs underlying the collective set of examined cognitive outcomes: (a) timed measures requiring minimal motor function and coordination, (b) timed measures requiring extensive motor function and coordination, and (c) non-timed measures. The fact that larger effects were found among variables comprising the first component suggests that Brain Age (and potentially other games) more specifically targets cognitive skills not requiring extensive motor function. Indeed, the challenge presented by the Card Sorting Tasks requires one to engage in planned and coordinated hand movements that cannot be easily learned via games like Brain Age. This finding further supports the view that the benefits of playing video games may be limited to skills that are directly practiced; however, two of the outcomes comprising the second construct (Extensive Motor Function) are the Trail Making Tasks, which are virtually identical to the activity practiced in Brain Age. While more work is needed to elucidate this matter, the principal component analysis findings offer further support for the hypothesis that the effects of video game training are generally larger among practiced outcomes.

Study 1 and 2 offer evidence indicating that both the Mini Arithmetic and Mini Syllable Count Assessments (MAA and MSA, respectively) serve as reliable assessments of speed of processing. In the case of the MAA, findings indicate it is strongly associated with various cognitive outcomes, both practiced and non-practiced measures. The strong relationships that the MAA holds with outcomes like the Trail Making Tasks and the Stroop Tests points to its convergent validity. Moreover, the negative association found between the MAA and the Raven's Matrices assessment was found to be similar in magnitude to that of both the Trail Making Tasks and the Stroop Tests; this points to the divergent validity of the measure. Lastly, findings stemming from the PCA analysis in which both measures loaded strongly on the same construct as did all three Stroop Tests further demonstrate each measure's construct validity. Though far from a Multitrait-Multimethod Matrix (MTMM) approach (Campbell & Fiske, 1959) to examining the issue, the present studies' findings suggest that the MAA and MSA may serve as a particularly useful measure of speed of processing and attention-related skills. Future work is needed to develop the reliability and validity of measures like MAA and MSA for examining the cognitive functioning of older adults.

Affective/Attitudinal Variables. Significant effects were observed among cognitive outcomes, but none were found among the examined affective/attitudinal outcomes. While not achieving statistical significance and not yielding effects as large as those obtained for cognitive outcomes, small positive effects were obtained for self-esteem (d = .23) and a measure of control/self-efficacy (d = .27). The observed difference in self-esteem attitudes indicates that the average participant in the intervention group reported greater feelings of self-esteem than did 59% of participants in the control group; likewise, the effect for feelings of control indicates that the average treatment group participant reported greater levels of control/self-efficacy than did 60% of participants in the control group. While no significant difference was obtained for either outcome, both effects point to what may potentially be additional benefits of playing video games like Brain Age. It is also worth noting that control/self-efficacy has received minimal attention when examining the impact of video game interventions (Hertzog et al., 2009), even though prior research has shown a strong link between self-efficacy and cognitive performance (Bandura 1989;

1993). Given the positive effects obtained herein, more work should investigate the conditions under which video game training interventions can have a meaningful effect on self-efficacy. One possible moderator is the nature of the self-efficacy assessment. That is, it is possible that video game interventions have less of an impact on global self-efficacy and, instead, a greater effect on specific forms of self-efficacy (Hertzog et al., 2009). So, while the current findings still demonstrate a small positive impact on self-efficacy, it is possible that more robust findings may be obtained by using an assessment instrument designed to more directly measure aspects pertaining to cognitive, or even video game, self-efficacy (i.e., self-confidence to improve cognitive functioning or in mastering technology).

Another noteworthy finding was the observed relationship between feelings of control and self-esteem (r = .52). This finding is consistent with the literature linking self-efficacy and self-esteem, and provides further support for the use of Krause’s (2001) measure of control as an indicator of self-efficacy among older adults. As discussed earlier, a compelling wealth of empirical support exists for the idea that self-efficacy and self-esteem reflect a common core construct (see Judge et al., 2002). The present study’s findings offer preliminary evidence that extends that view to older adult populations. These results present the possibility that video game interventions may improve older adults’ feelings of confidence in completing their goals, and to a similar extent, enhance their feelings of self-worth. More work is needed to further examine this link among older adults, particularly within the context of cognitive intervention studies, before any definitive conclusions can be drawn.

4.2 *Future Directions*

This study focused exclusively on healthy non-institutionalized older adults possessing relatively high levels of cognitive functioning. In line with the Cognitive Enrichment Hypothesis, it is possible that the higher level of cognitive functioning that the current study's participants possessed allowed for them to experience such dramatic increases in abilities. As noted earlier, according to the Cognitive Enrichment Hypothesis, the degree to which a cognitive intervention can affect cognitive abilities depends upon participants' upper limits of cognitive functioning. Therefore, while healthy older adults may no longer possess the level of cognitive functioning that they did in their earlier years, they possess the potential (or plasticity) to improve their cognitive abilities. The benefits of video games for improving older adults' cognitive functioning has been demonstrated for healthy individuals free of cognitive impairment; however, it is possible that individuals experiencing minor cognitive impairment (or even dementia) still possess some level of plasticity, which would allow them to enhance their cognitive functioning. Thus, interested researchers need to further elucidate whether highly accessible video games (like Brain Age) can also be useful in enhancing the cognitive abilities of older adults already experiencing cognitive impairment.

One limitation of the present study is that it leaves open the possibility that similar cognitive benefits could be obtained using non-technologically orientated tools. For instance, it stands to reason that gains in arithmetic and syllable identifying skills, along with Stroop-related attention skills, could be obtained using corresponding paper-based methods and a stopwatch. Future studies should employ a third comparison group to more closely examine the added benefit that the technology offers users. Another limitation is with regards to the lack of statistical power to adequately detect small to moderate effects. Despite the use of ANCOVA to enhance statistical power, findings stemming from Study 2 indicate a lack of statistical power to detect even moderate to large effects, as in the case of the Stroop Interference Test (d = .89) and the Mini Arithmetic Errors assessment (d = .59). On the other hand, Study 2 demonstrated the statistical power to detect particularly robust effects, as evidenced by the significant effects for the Mini Syllable Count and Mini Arithmetic Assessments (ds = 1.28 & 1.10, respectively). In addition, previous work examining the impact of video game interventions on cognitive functioning has generally uncovered large effects (d > .80), suggesting that even studies with small sample sizes may uncover significant effects. Thus, utilizing statistically meaningful covariates can uncover significant effects with samples of fewer than 40 participants. However, despite the challenges in obtaining large sample sizes when working in an applied setting with community-dwelling older adults, future studies should use larger samples.

One aspect that may distinguish video game interventions from corresponding paper-based versions is the engagement that they offer. Indeed, as noted earlier, a plethora of work has linked engagement offered by technologically-oriented educational tools and learning outcomes (Frederickson, Reed, & Clifford, 2005; Hattie & Timperly, 2007; Sosa et al., 2011). Degree of engagement, level of interactivity, and immediate feedback may each underlie the impact that video games have on cognitive functioning and potential increases in self-efficacy and self-esteem. Nevertheless, these facets have not been directly measured in the context of video game interventions. One possibility is to have independent judges rate the different technologies (either in the context of a single study or in a meta-analysis) along these characteristics and then examine the extent to which such facets are associated with improvements in cognitive performance and/or affective gains. Another limitation of the study is that is does not evaluate the degree to which the improvements obtained after five weeks persist over a more extended period of time. Given past work (see Hertzog et al., 2009 for a review), it is likely that participants experience degradation in skill after no longer using Brain Age. Future work should explore the nature of such decline in skill, asking, for instance, whether skills revert back to baseline levels within five weeks. A decline in abilities after discontinuing the training should not be surprising, nor should it be a reason to avoid undertaking video game training. Discontinuing a physical exercise routine will likely lead to muscle loss and decline in stamina; one has to regularly engage in physical exercise to sustain the gains achieved over time. In the same way, gains in cognitive abilities cannot be expected to remain if one ceases to engage in the very exercises that helped them achieve those milestones. Thus, video games should not be viewed as a “magic pill” for dramatically improving cognitive abilities. Instead, as with physical exercise, consistency is the key to achieving and maintaining cognitive performance.

4.3 *Significance*

Unlike most work examining the link between video games and well-being, the current study employed true experimental methodology in uncovering what, in some cases, amounts to robust findings. What many older adults/trainees may find to be the most meaningful aspect of the present study is, however, that improvements in cognitive abilities were brought about using a commercially available tool. Based upon the current findings, older individuals interested in realizing gains in specific cognitive skills need only borrow the handheld game from a relative or friend, or purchase the items themselves, and commit to playing it consistently.

There is great significance in identifying methods by which to prevent cognitive deterioration, particularly as it holds the potential to reduce health care costs in older age. There is evidence that playing computer games affects neurochemical levels positively (Koepp et al., 1998) and has a high potential for cognitive rehabilitation among people suffering from motor deficits (Cameirao, Bermúdez i Badia, Duarte Oller, Zimmerli, & Verschure, 2007). The evidence supporting the impact of Brain Age on cognitive abilities supports the view that off-the-shelf video games may be used to improve cognitive abilities among older adults. So long as consumers and medical professionals recognize that the benefits of such video game training may be limited to the specific skills that are practiced in the game, video games may serve as a viable option for the millions of older

Americans looking for an accessible and engaging way of improving cognitive skills. Indeed, findings support the idea of playing an assortment of engaging video games, each offering users an opportunity to improve upon additional cognitive skills. Thus, while the present findings are specific to Nintendo's Brain Age, they suggest that playing simple, inexpensive, and easily accessible video game can enhance cognitive skills among adults aged 65 and over.

Brain Age (along with other similar video games titles) may serve as a quick refresher tool for older adults looking to enhance specific cognitive skills. Lastly, the current study also addressed the need to empirically examine the validity of claims made by businesses, such as Nintendo, about the efficacy of technological products purported to improve cognitive functioning. As Hertzog et al. (2009) indicated, this is an issue with public policy implications, as most of the technological tools marketed to the public as improving cognitive functioning lack high-quality empirical support. Thus, given that software developers and purveyors generally do not provide solid empirical evidence to substantiate claims about their products, the current study holds significant implications for the establishing of such popular multimedia tools as valid and legitimate methods through which to improve cognitive functioning

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Appendix A

Correlations Between Pre-Test and Post-Test Cognitive Variables (N = 34-35)

	Post												
Pre	TA	TB	RAV	ART	ARE	SCT	SCE	CS1	CS2	CS3	STC	STW	STI
TA	.47**	.20	-.07	.27	-.07	.52**	.01	.35*	.37*	.47**	-.04	.13	.19
TB	.58**	.61**	-.30	.69**	.29	.36*	.27	.58**	.51**	.54**	.46**	.44**	.42*
RAV	-.64**	-.54**	.82**	-.57**	-.33	-.19	-.47**	-.45**	-.40*	-.38*	-.28	-.26	-.48**
ART	.28	.33	-.26	.74**	.14	.37*	.29	.27	.08	.03	.33	.30	.23
ARE	-.21	.20	-.37*	-.01	.36*	-.23	.15	.00	-.06	-.19	.02	-.23	-.05
SCT	.36*	.26	-.14	.35*	-.03	.73**	.09	.35*	.39*	.32	.12	.27	.38*
SCE	.11	.27	-.17	.19	.12	.30	.44**	-.02	.13	.20	.35*	.39*	.25
CS1	.52**	.13	-.38*	.25	-.15	-.06	.11	.82**	.56**	.37*	.27	-.01	.14
CS2	.46**	.28	-.38*	.36*	.00	.19	.18	.85**	.77**	.53**	.30	.19	.31
CS3	.31	.24	-.16	.24	.09	.42*	.25	.39*	.47**	.66**	.05	.03	.03
STC	.35*	.23	-.24	.63**	.24	.43**	.39*	.22	.15	.14	.67**	.65**	.49**
STW	.31	.17	-.13	.53**	.19	.39*	.30	.15	.21	.03	.52**	.76**	.43*
STI	.12	.07	-.25	.05	-.01	.25	-.05	.29	.44**	.12	.20	.34*	.45**

TA = Trail Making A
TB = Trail Making B
RAV = Raven's Matrices
ART = Mini-Arithmetic (Time)
ARE = Mini-Arithmetic (Errors)
SCT = Mini Syllable (Time)
SCE = Mini Syllable (Errors)
CS1 = Card Sorting Task 1
CS2 = Card Sorting Task 2
CS3 = Card Sorting Task 3
STC = Stroop Test (Color Patch)
STW = Stroop Test (Word Read)
STI = Stroop Test (Interference)

** $p < .01$ * $p < .05$

Appendix B

Correlations Between the Pre-Test and Post-Test Affective/Attitudinal Variables (N =29 – 35)

	Post Variables		
	Control (Post)	Esteem (Post)	Attitudes (Post)
Control (Pre)	.86**	.45*	-.01
Esteem (Pre)	.32	.71**	-.30
Attitudes (Pre)	-.17	-.03	.47**

**$p < .01$
*$p < .05$

Appendix C: Informed Consent Form (Study1)

The Video Games and Older Adults Project, conducted by Giovanni Sosa is designed to examine the effects of playing video games on the overall well-being of older adults.

The research will add to the limited literature we have concerning the many ways playing video games can impact the lives of older adults. We are hopeful that this information will help researchers, medical professionals, and members of the community understand how to use video games to improve the quality of life of the elderly.

The expected duration of the entire study will be approximately seven weeks. You will either be asked to complete two interviews (each lasting between 45-60 min) approximately five weeks apart, or in addition to the interviews, partake in a video game intervention that will require you to play video games for a period of five weeks (five hours per week). The risks from participating in this study include suffering a seizure or blackout during gameplay. Such risk is very small, but as a precaution, we ask that you refrain from participating if you, or anyone in your family, has ever suffered from an epileptic condition. Moreover, there is also a risk of experiencing fatigue while playing video games; playing any game for extended periods can cause fatigue in one's muscles, joints, skin, or eyes. As a result, we will be asking you to take frequent breaks during gaming sessions, and as a precaution, ask that you refrain from participating if you have a history of arthritis or carpal tunnel syndrome. Lastly, there is also the risk that you may suffer fatigue or emotional stress while completing each of the interviews. If the interviewer perceives that you may be experiencing emotional stress during the course of either interview, he or she will immediately terminate the research procedures. The risk for experiencing emotional stress, however, is very unlikely since these questions are not of an emotionally disturbing nature. Unfortunately, financial support for medical or counseling is not provided. Also, feel free to refrain from answering any questions during the course of the interview.

You will not directly receive monetary compensation for participation in this study; however, your respective Senior Center will be receiving compensation in the form of a sponsored social gathering. Moreover, you may or may not receive direct benefits for participating. However, the information resulting from this study will, at the very least, help researchers and medical professionals develop and utilize video game interventions to improve the well-being of older adults.

If you wish to voice a concern about the research, you may direct your question(s) to Research and Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA 91330-8232, or phone 818-677-2901. If you have specific questions about the study you may contact Giovanni Sosa by postal mail at 18111 Nordhoff Street, Northridge, CA 91330-8256, or by phone at 818-677-3555.

You should understand that participation in this study is completely voluntary, and you may decline to participate or withdraw from the study at any time without jeopardy. Likewise, the researcher may cancel this study at any time.

(over)

I have read the above and understand the conditions outlined for participation in the described study. I give informed consent to participate in the study.

Name ____

Last First

Age ________ Years ____________Months

Signature ____ Date ____________

Witness/P.I. signature _______________________________ Date ____________

If you have signed this form, please return it in an envelope by mail to:

Giovanni Sosa
Department of Psychology
California State University, Northridge
18111 Nordhoff Street
Northridge, CA 91330-8256

or give this form to Dr. Luciana Lagana` (same address).

Appendix D: Information Form (Study 2)

The Video Games and Older Adults Project, conducted by Giovanni Sosa, is designed to examine the effects of playing video games on the overall well-being of older adults. Specifically, it is designed to evaluate the effect that playing video games has on mental abilities, such as one's memory.

The research will add to the limited literature we have concerning the many ways playing video games can impact the lives of older adults. We are hopeful that this information will help researchers, medical professionals, and members of the community understand how to use video games to improve the quality of life of the elderly.

The expected duration of the entire study will be approximately seven weeks. You will be randomly assigned to one of two treatment conditions. One condition will entail having you completing two interviews (each lasting between 45-60 min) approximately five weeks apart. The second condition will entail having you not only complete the aforementioned interviews, but also partake in a video game intervention that will require you to play video games for a period of five weeks (three hours per week).

The risks from participating in this study include suffering a seizure or blackout during gameplay. Such risk is very small, but as a precaution, we ask that you refrain from participating if you, or anyone in your family, has ever suffered from an epileptic condition. Moreover, there is also a risk of experiencing fatigue while playing video games; playing any game for extended periods can cause fatigue in one's muscles, joints, skin, or eyes. As a result, we will be asking you to take frequent breaks during gaming sessions, and as a precaution, ask that you refrain from participating if you have a history of arthritis or carpal tunnel syndrome. Lastly, there is also the risk that you may suffer fatigue or emotional stress while completing each of the interviews. If the interviewer perceives that you may be experiencing emotional stress during the course of either interview, he or she will immediately terminate the research procedures. The risk for experiencing emotional stress, however, is very unlikely since these questions are not of an emotionally disturbing nature. Unfortunately, financial support for medical or counseling is not provided. Also, feel free to refrain from answering any questions during the course of the interview.

You will receive monetary compensation in the form of $20 that will be given to you within six weeks of completing the final assessment interview. Moreover, you may or may not receive additional direct benefits for participating. However, the information resulting from this study will, at the very least, help researchers and medical professionals develop and utilize video game interventions to improve the well-being of older adults.

If you wish to voice a concern about the research, you may direct your question(s) to Research and Sponsored Projects, 18111 Nordhoff Street, California State University, Northridge, Northridge, CA 91330-8232, or phone 818-677-2901. If you have specific questions about the study you may contact Giovanni Sosa by postal mail at 18111 Nordhoff Street, Northridge, CA 91330-8255, or by phone at 818-677-3555.

You should understand that participation in this study is completely voluntary, and you may decline to participate or withdraw from the study at any time without jeopardy. Likewise, the researcher may cancel this study at any time.

Appendix E: Physical Health Screener

1. Do you or anyone in your family suffer from Epilepsy?	Yes	No
2. Do you suffer from severe Arthritis (hands)?	Yes	No
3. Do you suffer from Carpal Tunnel Syndrome?	Yes	No
4. Do you suffer from Parkinson’s disease?	Yes	No

Appendix F: Demographic Questions

1) Date of Birth:________________ (Exact Age):_______________

2) Gender: Male________Female_________

3) Years of education

1. O Less than high school
2. O Graduated from high school
3. O Completed trade school
4. O Some college
5. O Bachelor's Degree
6. O Some Graduate School
7. O Master's Degree
8. O Ph.D., M.D., and/or J.D.

4) What is your total household income before taxes?

1. O Less than $20,000
2. O $20,000-$39,000
3. O $40,000-$59,000
4. O $60,000-$79,000
5. O $80,000-$99,999
6. O $100,000 or above

5) What is your racial/ethnic background?

1. O White/Caucasian
2. O White/Caucasian and some other races
3. O Black/African American
4. O Black/African American and some other race
5. O Hispanic/Latino
6. O American Indian or Alaskan Native
7. O Asian or Pacific Islander
8. O Other (please specify): **______________________**

Appendix G: Video Game Background/Experience with Puzzles

1) How many video OR computer-based games do you own? <u>Do not</u> include games legally downloaded for free or games that came with your computer, such as Solitaire.

□ I do not own any video games.
□ 1-5 games
□ 6-10 games
□ 11-20 games
□ 21-30 games
□ 31-50 games
□ 51-100 games
□ More than 100 games

2) I play video OR computer-based games:

Less than one time a month	About one time a month	Several times a month
Several times a week	Every day	**N/A**

3a) In the last 5 weeks, have you attempted or completed any puzzles (e.g., crossword puzzles)? No Yes

3b) If you answered 'Yes' to question 3a, about how many puzzles have you attempted in the last 5 weeks? ______________

3c) If you answered 'Yes' to question 3a, about how many puzzles have you completed in the last 5 weeks? ______________

3d) If you answered 'Yes' to question 3a, did you complete any of the puzzles on the computer/internet or any other electronic source (e.g., video game)? No Yes

Appendix H: The Memory Alterations Test

Encoding

'Try to remember these words. It is important to pay close attention'

Repeat please: **cherry (R) axe (R) elephant (R) piano (R) green (R)**

1. I told you the name of a fruit, what was it?	**0–1**	**(If 0, repeat the correct answer)**
2. I told you the name of a tool, what was it?	**0–1**	"
3. I told you the name of an animal, what was it?	**0–1**	"
4. I told you the name of a musical instrument, what was it?	**0–1**	"
5. I told you the name of a color, what was it?	**0–1**	"

'Later on I will ask you to recall these words'

'Please pay attention to these sentences and try to remember them' (maximum 2 trials):
Please repeat: Thirty grey cats ate all the cheese (R)

6. How many cats were there?	**0–1**
7. What color were they?	**0–1**
8. What did they eat?	**0–1**

(If 0 tell the subject the correct answer)

Please repeat: A boy named Louis was playing with his bicycle (R) (maximum 2 trials):

9. What was the boy's name?	**0–1**
10. What was he playing with?	**0–1**

(If 0 tell the subject the correct answer)

Temporal orientation

11. Day of week	**0–1**
12. Month	**0–1**
13. Date	**0–1**
14. Year	**0–1**
15. Season	**0–1**

Semantic memory

(2 trials; if the subject is wrong, repeat the question)

16. What is your date of birth?	**0–1**
17. What do you call someone who repairs cars?	**0–1**
18. What was the name of the last president?	**0–1**
19. What is the last day of the year?	**0–1**
20. How many days are there in a year?	**0–1**
21. How many ounces are there in one quarter of a pound?	**0–1**
22. What is the 8th month of the year?	**0–1**

23. When is Christmas day? **0–1**
24. If the clock shows 11 o'clock, what number does the long hand point toward? **0–1**
25. Which season comes after summer? **0–1**
26. In the Bible, which animal deceived Eve with an apple? **0–1***
27. Which fruit is necessary to make wine? **0–1**
28. Which plant is necessary to make chocolate? **0–1**
29. What is three times the number one? **0–1**
30. How many hours are there in two days? **0–1**

Free recall

31. How many words that I said at the beginning can you remember? **0–1–2–3–4–5**
(Wait for the answer minimum 20 sec. You may repeat the question twice)
32. Do you remember anything from the sentence about cats? **0–1–2–3**
(1 point per idea:30–Gray–cheese)
33. Do you remember anything from the sentence about a boy? **0-1-2**
(1 point per idea: Louis–cycle)

Cued-recall

34. I told you the name of a fruit, what was it? **0–1**
35. I told you the name of a tool, what was it? **0–1**
36. I told you the name of an animal, what was it? **0–1**
37. I told you the name of a musical instrument, what was it? **0–1**
38. I have told you the name of a color, what was it? **0–1**

'Try to remember the sentence about cats . . .'

39. How many cats were there? **0–1**
40. What color were they? **0–1**
41. What did they eat? **0–1**

'Try to remember the sentence about a boy . . .'

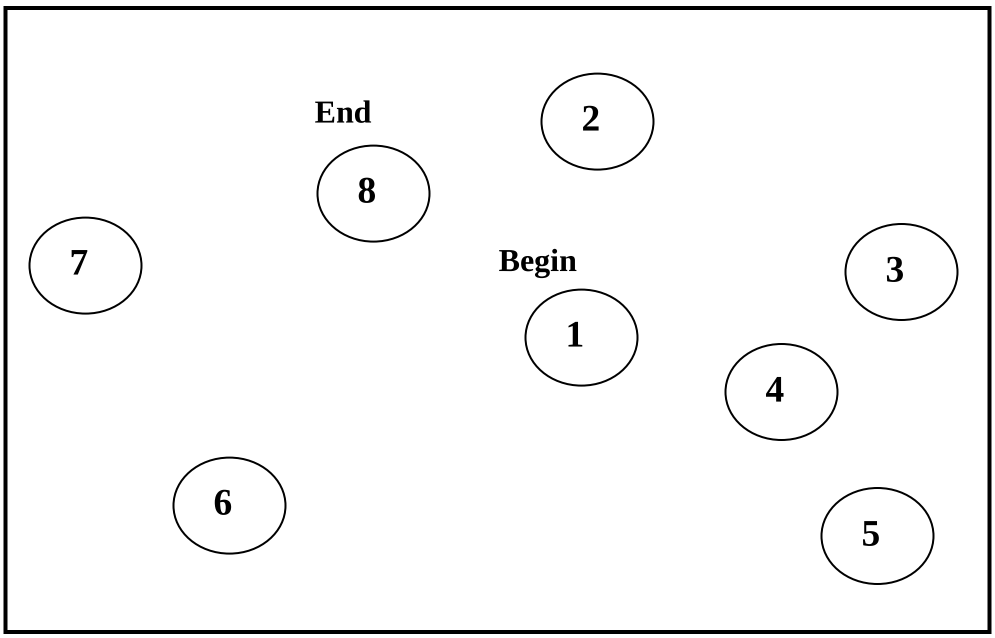
42. What was the boy's name? **0–1**
43. What did he play with? **0–1**
(Score 1 point for each word provided in the preceding question)

*Omitted from employed version of the tool.

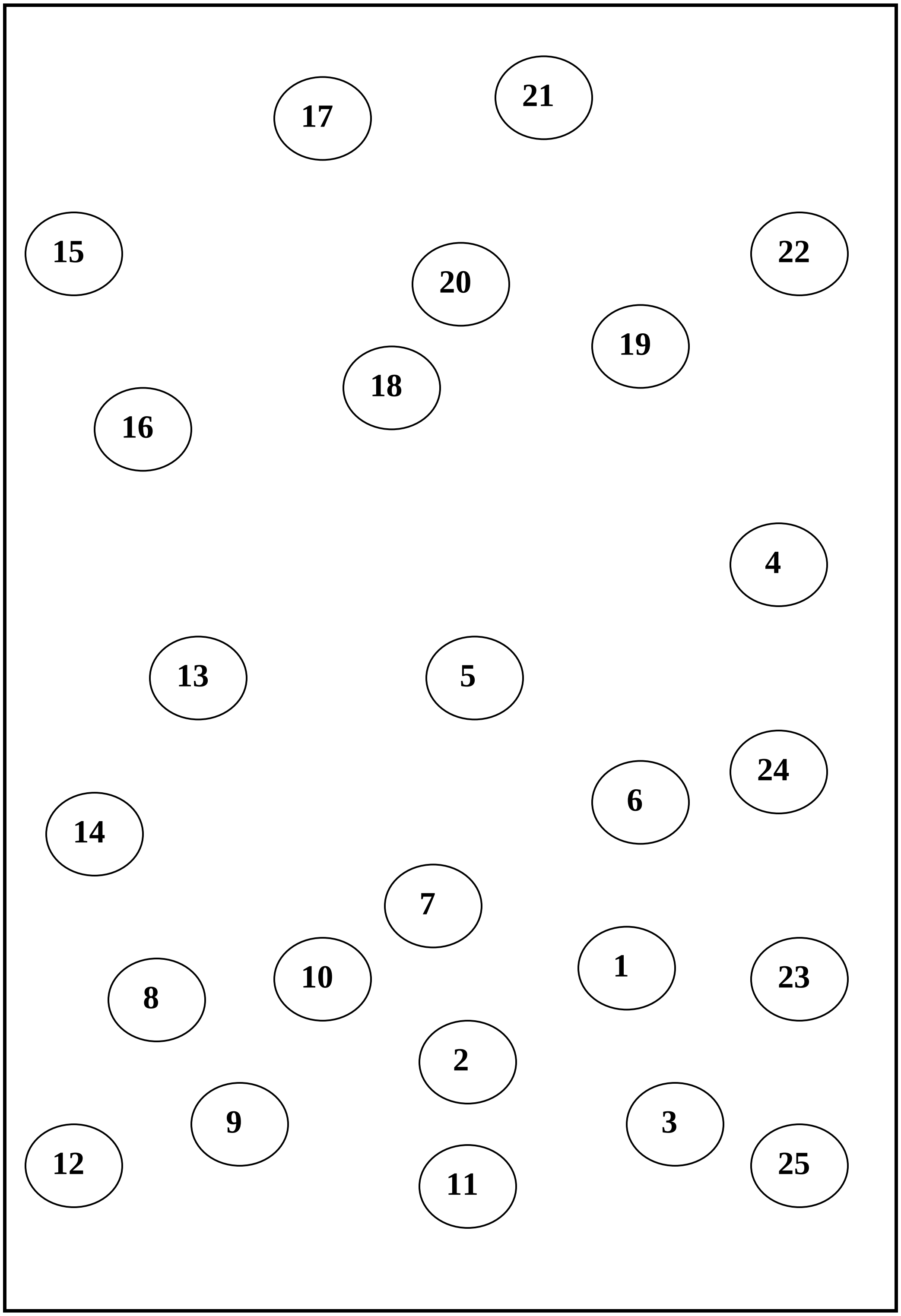
Total Score: ____________

Appendix I: Trail Making Tasks A and B

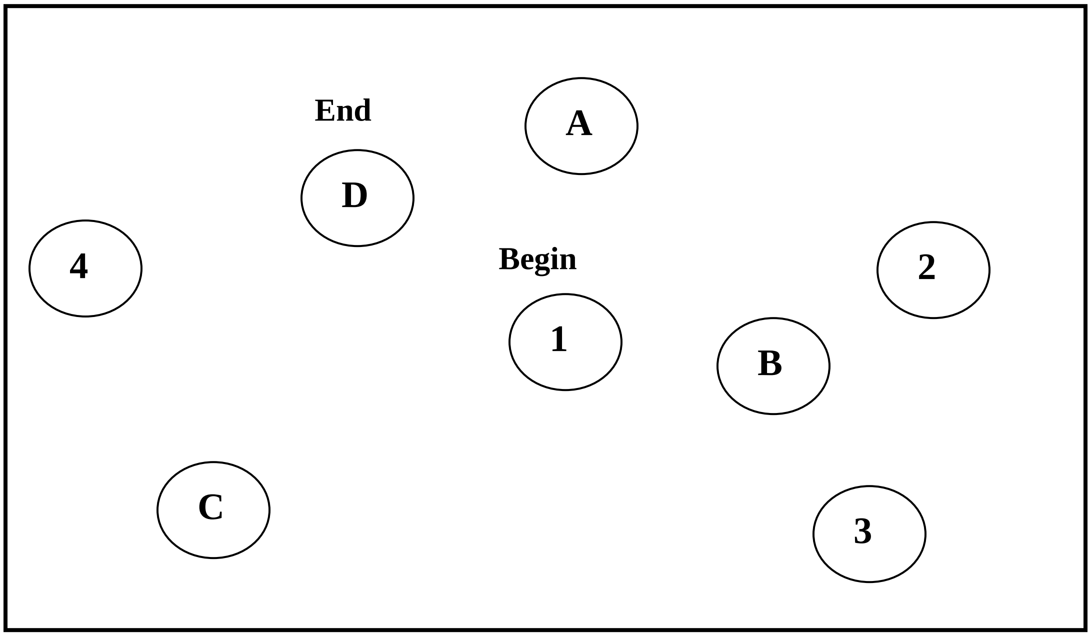
TRAIL MAKING (PART A)-*SAMPLE*



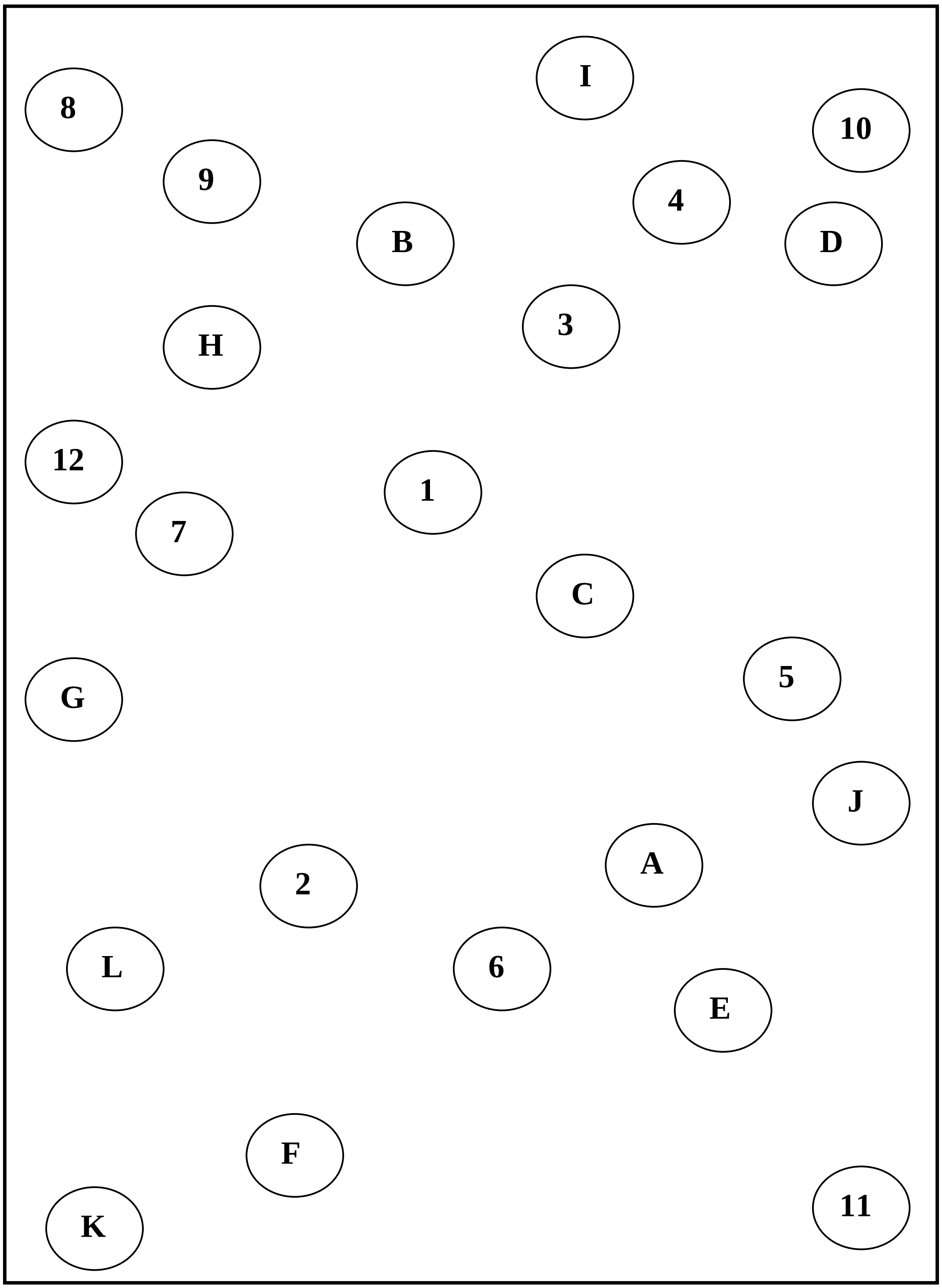
TRAIL MAKING (PART A)



TRAIL MAKING (PART B)-*SAMPLE*



TRAIL MAKING (PART B)



Trail Making Task

Interviewer: Please record the times for each task below

- **Example: 1:45.4**

Part A

Time to Completion (to nearest tenth):______________________

Did participant make a mistake on Part A? no yes

Part B

Time to Completion (to nearest tenth): ______________________

Did participant make a mistake on Part B? no yes

Appendix J: Mini Arithmetic Assessment

Interviewer: Read the following to the participant:

"I will now ask you to complete a task requiring you to solve addition, subtraction, and multiplication problems. Let's practice (correct any errors):"

1+3 = ___________

7x2 = ___________

Once both practice problems have been completed, say:

"Good. On the back of this sheet you will find 20 more problems to solve. Flip the page when you are ready".

Once the participant turns the page over, start timing. Record the time and the number of errors below:

Sample Recorded Time: 1:45.4

Time to Completion (to nearest tenth):______________________

Number of Errors:______________________

1. 2+0 __________

2. 5x9 __________

3. 7+7 __________

4. 7x0 __________

5. 7-0 __________

6. 7-2 __________

7. 1+1 __________

8. 8x4 __________

9. 3+2 __________

10. 14-7 __________

11. 8+3 __________

12. 2x6 __________

13. 4x3 __________

14. 10-8 __________

15. 6x5 __________

16. 9+4 __________

17. 4x2 __________

18. 5-2 __________

19. 5-1 __________

20. 6+5 __________

Appendix K: Mini Syllable Count Assessment

Interviewer: Read the following to the participant:

"I will now ask you to complete a task requiring you to identify the number of syllables for each of seven phrases. A syllable is a basic unit of speech generally containing only one vowel sound. For instance, the word *basic* contains two syllables (*ba-sic*). The word *generally* contains four (*gen-er-al-ly*). Now let's practice; how many syllable are there in the following two phrases (correct any errors):"

She read to the boy

____

Rabbits love carrots

____

Once both practice phrases have been completed, say:

"Good. On the back of this sheet you will find seven more phrases for which you must identify the number of syllables. Flip the page when you are ready".

Once the participant turns the page over, start timing. Record the time and the number of errors below:

Sample Recorded Time: 1:45.4

Time to Completion (to nearest tenth):_____________________

Number of Errors:_____________________

SYLLABLE COUNT

Dead men tell no tales.

____

Climb onto your seahorse now.

____

She danced in the moonlight of the night.

____

An apple a day keeps the doctor away.

____

Syllables influence the rhythm of written language.

____

Diane and Becky went to Disneyland for the very first time.

____

They lived happily ever after and rode off into the sunset on their horse.

____

Appendix M: Card Sorting Tasks (1-3)

Interviewer: Read the following to the participant:

"The following tasks require that you sort a deck of 52 cards into several categories. The time to completion will be measured using a stopwatch."

Please demonstrate each task before commencing. Do not count self-corrected errors.

Please also remember the following: (a) after completing each activity and counting the number of errors, please shuffle the deck before beginning the following activity, (b) ask them to keep the cards face up while they are holding them, and (c) before beginning activity 3, explain the ranking system (i.e., Ace, Jack, Queen, King).

- **Sample time:** 1:45.4

Activity 1

Please sort the deck of cards into two distinct piles by color.

Time to completion (record to nearest tenth): ______________________

Number of Uncorrected Errors: ______________________

Activity 2

Please sort the deck of cards into four piles according to suit.

Time to completion (record to nearest tenth): ______________________

Number of Uncorrected Errors: ______________________

Activity 3

Please sort the deck into 13 piles according to rank.

Time to completion (record to nearest tenth): ______________________

Number of Uncorrected Errors: ______________________

Appendix N: Global Feelings of Control

1. **I have a lot of influence over most things that happen in my life**:
   1 – Strongly Agree
   2 – Agree
   3 – Disagree
   4 – Strongly disagree
   7 – Not Sure
   9 – N/A

2. **I can do just about anything I really set my mind to**:
   1 – Strongly Agree
   2 – Agree
   3 – Disagree
   4 – Strongly disagree
   7 – Not Sure
   9 – N/A

3. **When I make plans, I'm almost certain to make them work:**
   1 – Strongly Agree
   2 – Agree
   3 – Disagree
   4 – Strongly disagree
   7 – Not Sure
   9 - N/A

4. When I encounter problems, I don't give up until I solve them:
   1 – Strongly Agree
   2 – Agree
   3 – Disagree
   4 – Strongly disagree
   7 – Not Sure

Appendix O: Rosenberg Self Esteem Scale

1. STRONGLY AGREE
2. AGREE
3. DISAGREE
4. STRONGLY DISAGREE

Instructions: PUT THE CHOSEN NUMBER NEXT TO EACH QUESTION

___ 1. I feel that I am a person of worth, at least on an equal basis with others.

___ 2. I feel that I have a number of good qualities.

___ 3. All in all, I am inclined to feel that I am a failure.

___ 4. I am able to do things as well as most other people.

___ 5. I feel I do not have much to be proud of.

___ 6. I take a positive attitude toward myself.

___ 7. On the whole, I am satisfied with myself.

___ 8. I wish I could have more respect for myself.

___ 9. I certainly feel useless at times

___ 10. At times I think I am no good at all.

Appendix P: Video Game Attitudes Scale

1) I like the idea of using video OR computer-based games to improve one's mental functioning

strongly disagree	moderately disagree	disagree a little	neither agree or disagree	agree a little	moderately agree	strongly agree

2) Video AND computer-based games are intended to be used only by young people

strongly disagree	moderately Disagree	disagree a little	neither agree or disagree	agree a little	moderately agree	strongly agree

3) I have no interest in learning how to play video games.

strongly disagree	moderately Disagree	disagree a little	neither agree or disagree	agree a little	moderately agree	strongly agree