COGNITIVE TRAINING WITH VIDEO GAMES TO IMPROVE DRIVING SKILLS AND DRIVING SAFETY AMONG OLDER ADULTS

By

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To my grandparents, for their unconditional love

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Visual attention is one of the most important cognitive skills required for driving an automobile. Although this skill declines with aging, training in older ages has been shown to boost visual attention. Today the most approach for training older adults' visual attention is the UFOV. A practical drawback of using this training, however, is that equipment demands require that the training be done in a laboratory or clinical setting, which can be expensive and inaccessible for the general population. Given the importance of visual attention for driving performance and given the lack of widely available approaches to train this skill, there is a need to explore more inexpensive alternatives for training visual attention. One possible option for training visual attention in older individuals involves video games. Previous research with younger adults has shown positive effects of video game in training on the visual attention of college students, including in useful field of view tasks.

The current study investigated the impact of video game training on older adult's visual attention performance; in addition, it was investigated if such improvements would transfer to improved performance in a driving simulator task. Fifty-eight participants. Forty-five participants were assigned to one of the three intervention groups (action video game (Medal of

Honor), Useful Field of View (UFOV), placebo control video game (Tetris)) and thirteen participants were assigned to a no contact control group. Before training and immediately after training participants from the intervention groups were evaluated in a UFOV test and in a driving simulator test. The intervention was composed of 6 training sessions, each of 1.5 hour duration.

Overall, the results suggest that the UFOV training improved visual attention significantly more than any other group. It was noted, however, that the two video game conditions (Medal of Honor and Tetris) experienced (non-significantly) more visual attention gain than the no contact control group; indeed, on one subtask (Selective attention), the Tetris group experienced significantly more gain than the no-contact control group, even though Tetris had been construed as a no-contact control. Despite general practice-related gain in driving simulator performance for all study groups, the results of the study further indicated that the visual attention gains were not transferred to a simulator driving performance.

In contrast, differential effects of the three training conditions were observed in participant Flow, an indicator of participant enjoyment and engagement. Participant's self-rated flow experience suggested that enjoyment improved over time for the two video game conditions (Medal of Honor, Tetris), but decreased for the more traditional computer-based UFOV training group. In a final study aim, consumer-oriented analyses of participants' opinions about the games they played were conducted. Results of these analyses suggested that video game were acceptable to this older adult population, and that many saw the games as a valid tool for mental exercise. Thus, although more work is needed to establish appropriate dosages, outcome measures, and to identify which games best improve visual attention, the positive evaluations of the games and positive Flow results lend preliminary support that video games can be acceptable and promising intervention tool.

CHAPTER 1
INTRODUCTION

Driving

Driving is a very important activity for older adults in the United States. It is a means for achieving independence and social connectedness in American society, especially for those living in rural areas. In addition, it is linked to other activities of daily living. Isolation and depression are commonly associated with driving cessation or reduction (Marotolli, Mendes de Leon, Glass, Williams, Cooney Jr, Berkman, et al., 1997; Fonda, Wallace, & Herzog, 2001).

It is estimated that 89% of American seniors conduct their travel in personal vehicles (Collia, Sharp, & Giesbrecht, 2003). The total trip miles traveled by people aged 65 and older increased by 21 percent compared to total trip miles traveled by people aged 25-64 between the years 1995 and 2001. The average trip miles per person also increased 13 percent for those 65 and older, but stayed almost the same for the younger group (Austin & Faigin, 2003).

With the increase in life expectancy, the number of older adults driving automobiles is also increasing. It is estimated that by the year 2050 the elderly population will increase to 79 million persons, more than double its present size (US Census). Older drivers represent 10 percent of the total driving population in America and, the number of licensed and frail elderly is projected to increase. In 2002, the elderly population accounted for 150,000 injuries associated with vehicle crashes or 5% of all people injured in crashes (NHTSA, 2002). This suggests that older drivers' safety should be considered a public health issue.

Driving is a very complex task that involves several factors, such as mobility, sensory function, cognition, and the environment per se (e.g., road and vehicle design). Driving can be a challenge for older individuals due to normally declining factors associated with aging. While many older adults can modify their driving habits (e.g., drive less, drive only during restricted

hours) due to sensorimotor or cognitive impairments, many continue to drive as long as possible and do not change their preferred mode of travel (Ball, Owsley, Stalvey, Roenker, Sloane & Graves, 1998). This behavior puts older drivers at increased risk for crashes. Older drivers are at a greater risk for crashes and traffic convictions, per capita, than any other adult age group (Owsley, Ball, Sloane, Roenker & Bruni, 1991; Edward Roybal Center for Research, 2001). Older drivers with visual and cognitive declines are at a greater risk for crash involvement than those who do not have similar deficits (Owsley et al., 1991).

Among all the possible cognitive skills related to driving, visual attention has consistently been found to be one of the most associated factors. It plays a major role in driving performance (Owsley, et al., 1991; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Richardson & Marottoli, 2003). Visual attention is commonly defined as the focal area from which information can be acquired within one eye fixation or "glance" (Ball, Beard, Roenker, Miller & Griggs, 1988).

Richardson et al., (2003) found that visual attention is the cognitive skill related to driving behaviors that is most problematic for older individuals. In their study, driving behavior was assessed through a road test that included 36 items (e.g., acceleration, braking, lane change, speed regulation, response to traffic signals). Visual attention was the cognitive skill most associated with driving behaviors. Out of 36 maneuvers, 25 required the use of visual attention skills (e.g., yielding right of way, responding to other vehicles or pedestrians, making turns at an intersection). In a similar study, Ball and Owsley (1991) investigated the types of crashes in which older adults are most likely to be involved. They found that major crashes among older individuals are more likely to occur at intersections, where the visual attention requirements (detection, localization and identification of targets) are more likely to be higher.

Several cognitive tests have been used to investigate the relationship between cognitive skills and car crashes. Scores on the Useful Field of View (UFOV) test, which is a measure of speed of processing and visual attention, show the highest relationship to crash involvement in a number of studies (Goode, Ball, Sloane, Roenker, Roth, Myers, et al., 1998). Thus, several studies on visual attention have used the UFOV to operationalize this construct. UFOV is said to decrease with aging (Sekuler, Bennett & Mamelak, 2000). Thus, the deficit in UFOV associated with aging is a putative cause of increased late-life risk for crashes and driving errors. This age-related loss of UFOV skill may not be irreversible. A growing body of evidence suggests that training of this skill may be effective well into late life.

UFOV performance can be improved with training. The ACTIVE clinical trial, a multi-site NIA-funded study of cognitive interventions with older adults, employed a ten-session training program for older adults. Participants received customized training (at their level of ability) and strategy instruction, with extensive practice of sample exercises using a touch screen computer. Initial findings from the ACTIVE study found an increase in the size of the UFOV immediately following the training (Ball, Berch, Helmers, Jobe, Leveck, Marsiske, et al., 2002), and that these gains were maintained for at least two years. Moreover, a longer-term follow-up with ACTIVE participants further revealed that persons who received UFOV training continued to show performance advantages on UFOV tests, relative to untrained controls, up to five years after training (Willis, Tennstedt, Marsiske, Ball, Elias, Koepke, et al., 2006).

In accordance with the positive results seen in the ACTIVE trial, today the most common tool to train older adults' visual attention is the UFOV training program, developed by investigators at Western Kentucky University and the University of Alabama-Birmingham. UFOV training, as in ACTIVE, is practiced in a touch screen environment using specialized

equipment and software. A drawback of using this training is that equipment demands require that the training be done in a laboratory or clinical setting, which can be expensive and inaccessible for the general population. Given the importance of visual attention to driving performance and given the lack of widely available instruments to train this skill, there is a need to explore more inexpensive alternatives for training visual attention.

A possible option for training visual attention in older individuals is the use of video games. Previous research with younger adults has shown positive effects of video games playing in the training of visual attention in college students (Green & Bavelier, 2003). Although there is evidence that video game playing enhances motor, perceptual, and cognitive abilities among the elderly (Drew & Waters, 1986; Clark, Lanphear, & Riddick, 1987), the use of video game playing to train visual attention among the older population has not been investigated.

Above-and-beyond the practical value of exploring video games as a tool for training visual attention (i.e., video games use widely available and a more affordable technology), a secondary reason that video games might be worthwhile exploring concerns enjoyability of or engagement in the training experience. Video games have been designed, after all, to be "fun".

Thus, video games may provide a motivating and engaging tool to increase visual attention in elders; such motivational benefits may enhance compliance with and effort in training. Thus, an important piece of information which needs to be collected in video game training studies with older adults concerns their engagement and motivation to use this technology. Engagement in activities often uses "Flow" theory, as described by Csikszentmihalyi (1975), and forms a core concept in the current study. This is described in further detail in the next chapter.

The use of training strategies to improve cognitive skills in old age and therefore, improve performance of instrumental activities of daily living (e.g., driving) can be put into perspective

by using a conceptual model recognized in rehabilitation science. The World Health Organization (WHO), International Classification of Function, Disability and Health (ICF), will be used as the framework for this study (Figure 1-1). The ICF provides a good understanding of the use of cognitive training in rehabilitation settings. It also provides the basis for understanding the interrelationship between the person, the environment, health and function.

The International Classification of Function Disability and Health (ICF)

The ICF (International Classification of Functioning, Disability and Health) is a member of the World Health Organization Family of International Classifications. It defines a new model of health. ICF is the result of a revision in the previous model ICIDH (International Classification of Impairment Disability and Handicap), created in 1980 to fulfill the need for a model that could capture the multidimensional aspect of disability. Prior health assessment had focused on mortality and cause of death. Within this new perspective, the individual level of functioning was also considered as a component of health. The ICIDH had many limitations, one of them being that the linear progression of the model (from impairments to disability and handicaps) could not really capture the multidimensional aspect of disability. Thirteen years after its approval, ICIDH went through an in depth review process that lasted 10 years. ICF emerged from this process. It uses a neutral terminology that can be applied to every person regardless of their health status. In addition it uses a standardized language which facilitates the communication of health professionals around the globe. The ICF model brings together the medical model (which views disability as a problem exclusively of the person) and the social model (which views disability as a problem exclusively of the environment) to create a biopsychosocial model of health, which takes into account the body, the individual and society. In contrast to its earlier version (ICIDH), health is seen in a dynamic process; the environmental component was added to this model, and it is a very important factor in the understanding of multidimensional aspects of health (Üstun,

Chatterji, Bickenback, Kostanjsek & Schneider, 2003). ICF has multiple applications in the area of rehabilitation.

ICF Classification

The goal of the ICF is to classify all aspects of health and health related states (World Health Organization [WHO], 2001). ICF information is organized in two parts*:* Functioning and disability and contextual factors. These parts are further categorized into components. The components of functioning and disability include body functions and structures, activities and participation. Body function encompasses the physiological function of the body system whereas body structure encompasses the anatomical part of the body. Activity is defined as the execution of a task whereas participation is defined as an involvement in a life situation. Activities and participation also involve two other constructs: capacity and performance. Capacity is the ability to execute a task in a standardized environment and performance is the ability to execute a task in the real environment. The components of contextual factors include: environmental factors and personal factors. Environmental factors are related to the physical, social and attitudinal environment. Personal factors pertain to the individual background (e.g., lifestyle, age, culture, race).

ICF provides its classification through a coding system for recording functioning and disability status under each component of the model. The classification can use from two to four levels of coding. Codes are represented by an alphanumeric system. The letter “b” denotes components of body functioning; “s” denotes components of body structure; “d” denotes components of activities and participation and “e” denotes environmental factors. The first level coding involves the letters followed by a numeric code that involves the number of a chapter. For example: “d9” denotes community, social and civic life. The next level coding has two digits, and will further classify the previous level, for example “d920” denoted the recreation and

leisure. To indicate the level of health or severity of the problem in each domain, “qualifiers” are placed after a decimal point following the category code. A body function qualifier indicates the presence of impairment (on a five point scale e.g., no impairment, moderate impairment). Body structure qualifiers indicate the extent of impairment (e.g., no impairment, mild impairment), nature of body structure (e.g., no change in structure, partial absence, additional part) and localization (e.g., right, left, both sides). A capacity qualifier describes the ability to execute a task in a standardized environment (no support is provided by the environment, e.g., execution of a task without assistive device). A participation qualifier describes the ability to execute a task in the current environment (with support form the environment, e.g., use of assistive device). An environmental factor qualifier describes the extent to which the environment has enabled (facilitator) or limited (barrier) performance. Both of them use a generic qualifier (0-4 scale), but facilitators are specified by replacing the decimal point with “+”. Personal factors are not coded in the ICF.

A problem in the body function and structures will cause impairment, while a problem in executing activities or engaging into life situations will cause an activity limitation or participation restriction respectively. Disability then is a broad term that encompasses the negative aspects of health (impairment, activity limitation and participation restriction). It is viewed by WHO as an outcome of interactions between health conditions and contextual factors. On the other hand, the successful completion of everyday activities across a wide range of life areas is termed functioning.

Functioning and disability in the ICF are seen as an interactive and evolutionary processes. Each entity of the model interacts in a dynamic and non linear relation. For instance; an individual may have performance problems without impairment or capacity limitation (e.g., an

ex-prisoner facing discrimination and not able to engage in any social relationship). Furthermore, intervention in one domain has the potential to modify one or more domains. For example, the use of an assistive device can facilitate execution of a task and in turn facilitate social interaction. An individual with low vision has a telephone with large keys, being able to perform the task of dialing – activity - and making phone call to friends engaging in social interactions – participation.

ICF classification is used to obtain information of a person functioning instead of a classification of people with disability. From this perspective, ICF can be used for everybody, independent of one's level of health. ICF does not describe disability as a consequence of health condition; it also involves legislation, attitudes, physical, social environments. The environmental factor in this model is a key aspect for understanding functioning and disability because disability must be seen in the societal context (Dahl, 2002).

ICF has an important role in rehabilitation. In contrast to medical interventions that focus on the disease process, rehabilitation has a broader understanding of the individual, which view function and health as also associated with personal and environmental factors (Stucki, Ewert & Cieza, 2002). In this study, the use of cognitive strategies to promote cognitive skills is related to personal factors, and is associated with each level of the ICF model, as will be described below.

Application of Leisure / Recreation Based Approaches to Maintaining / Enhancing Cognition and Complex Activity Performance Application at Each Level in the ICF

A set of studies on participation in leisure activities in later life found a relationship between leisure activities and cognition in later life. A stimulating environment provided by participation in leisure activities has the potential to improve cognitive capacity and would reflect in each level in the ICF. From this perspective, participation in leisure activities will be classified as a lifestyle. Lifestyle seems to represent a number of different constructs, among

them is participation in leisure activities (Scarmeas & Stern, 2003). Richards, Hardy and Wadsworth (2003), studied the effect of participation in leisure activity in a sample of 5362 individuals over a 43-year period, and found a positive association between participation in leisure activities through the lifespan and cognitive functioning. An active lifestyle might enhance functioning in later life and be an important approach for successful aging.

Rowe & Kahn (1997), conceptualize successful aging as a hierarchy that consists of three tasks: 1. Decreasing the risk of disease and disease-related disability, 2. Increasing or maintaining physical and mental functioning and 3. Being actively engaged with life. Participation in mental activities in later life has a positive impact on one's life and can influence each task in the model proposed by Rowe and Kahn.

Several studies found a positive relationship between participation in leisure activity and cognitive functioning in later life. These studies give us a broad perspective on the importance of participation in leisure activity for enhancing or maintaining cognition in later life. Cognitive ability is not fixed, but environmental factors play a role in augmenting cognitive functions in later life.

Participation in activities that are cognitively demanding is related to cognitive reserve in later life. One of the studies related to this topic was conducted by Wilson, Barnes and Bennett (2003). In this study, older individuals were asked to rate their frequency of participation in common cognitive activities (e.g., reading, playing games like checkers, visiting a library) at five points in time (age 6, 12, 18, 40 and currently). Results show that lifetime cognitive activity was related to semantic memory, perceptual speed and viso-spatial abilities.

Scarmeas, Levy, Tang, Manly and Stern. (2001), proposed that leisure activities also contribute to the cognitive reserve by preserving a set of skills or repertoires necessary for

cognitive function. Participants of this study were 1,772 non-demented individuals who were examined annually, up to 7 years.

There is also a relationship between levels of cognitive demands in the activities and levels of cognitive function. Singh-Manoux, Richards and Marmot (2005) conducted a study to examine the relationship of leisure activities and cognitive functions. In this study, participants rated their frequency in participation in cognitive activities. Activities were classified as either having high or low cognitive effort. High demanding cognitive activities were associated with higher cognitive abilities. In addition activities that required social interactions had a higher cognitive demand than activities that did not required social engagement.

Research has also supported the notion that the increase in brain cognitive reserve by participation in leisure activities lowers the risk of dementia, both Alzheimer's disease and vascular dementia. Participation in an activity for one day per week, can reduce the risk of dementia by 7 percent. Although participation in cognitively stimulating activities is associated with reduced risk of dementia, participation in physical activity is not (Verghese, Lipton, Katz, Hall, Derby, Kuslansky, Ambrose, Sliwinski & Buschke (2003).

According to these studies, lifestyle is related to cognitive functions in later life. In the ICF model, lifestyle is classified under personal factors. In this case, lifestyle would augment cognitive function in later life. Although ICF does not use "facilitators" and "barriers" as qualifiers for personal factors, it seems that participation in leisure activities functions as a facilitator to the maintenance or enhancement of cognitive functions in later life. Future studies should be done to examine the applicability of these two qualifiers under personal factors. Furthermore, a relationship is found in the model between personal factors (in this case lifestyle) and environmental factors. Lifestyle can influence or be influenced by environmental factors. For

instance, if a person lives in a resource-rich environment, this person will be more willing to have a lifestyle that accounts for improvement in cognitive functioning. The availability of programs that would promote participation in leisure activities program for older adults in the community would act as an environmental facilitator for leisure participation.

Participation in Leisure Activities Impacts all Components of ICF Model

Body Structure - As the results of previous studies indicate, participation in leisure activities contributes to cognitive reserve. Cognitive reserve is a term commonly used to explain the great variability in the severity of cognitive aging in the face of neurodegenerative changes that are similar in nature and extent. Studies suggest that cognitive reserve probably involves processes that support neuroplasticity, which is defined as the "self-organization of the brain to meet environmental demands (Whalley, Deary, Appleton & Starr, 2004). Scarmeas and Stern, (2003), suggests different ways in which leisure activities may enhance cognitive reserve: First, an engaged lifestyle may increase synaptic density in neocortical association cortex, second, better circuits of synaptic activity may exist in subjects who participate in leisure activities (even though the number of neurons or synapses might be the same) and third, more efficient use of brain networks. ICF gives classifications of structure of the brain under "body structure" component, under code "s110".

Body Functioning - Studies discussed in this section indicated that participation in cognitive stimulating activities, specifically leisure activities, reduce the decline of memory (Verghese et. al., 2003; Wilson et. al., 2003; Singh-Manoux et. al., 2005) inductive reasoning, verbal meaning, verbal fluency (Singh-Manoux et al., 2005), perceptual speed, visuo-spatial ability (Wilson et. al., 2003). The classification of cognitive functioning in found in the ICF under "body functioning". Cognitive functioning can be classified under global functioning and specific mental functions.

Activities and participation - The performance of activities of daily living (ADL) and instrumental activities of daily living (IADL), such as driving, involves the use of fundamental cognitive skills. Studies show that poor cognitive function leads to increased risk of limitation in ADL performance (Moritz, Kasl, & Berkman, 1995). In this case, lifestyle would not specifically affect participation in leisure activities, but lifestyle would increase cognitive function needed to perform all the array of everyday activities. All activities classified in the ICF could be affected by enhancing cognitive capacity.

The potential of using ICF to classify cognitive disorders has already being stated (Arthanat, Nochajski & Stone, 2004), however, in the present discussion, the personal level, defined as positive lifestyle by participation in leisure activities, was added. Thus, the use of cognitive training to promote cognitive function can be seen as part of the personal component, and has the potential to influence each level of the model by improving visual attention (body function and structures level), having an impact on driving performance (activities level) and promoting independence in other activities by driving (participation level).

Study Purpose

The purpose of this study was to investigate the efficacy of using an action video game (Medal of Honor; MOH) to improve the visual attention (UFOV) performance of older adults. The study also investigated the effects of MOH training on a “real-world” outcome of older adults’ simulated driving performance. Another purpose of this study was to investigate participants’ engagement with/enjoyment of videogame- or UFOV-training, and to query participants' opinions about exiting interface design.

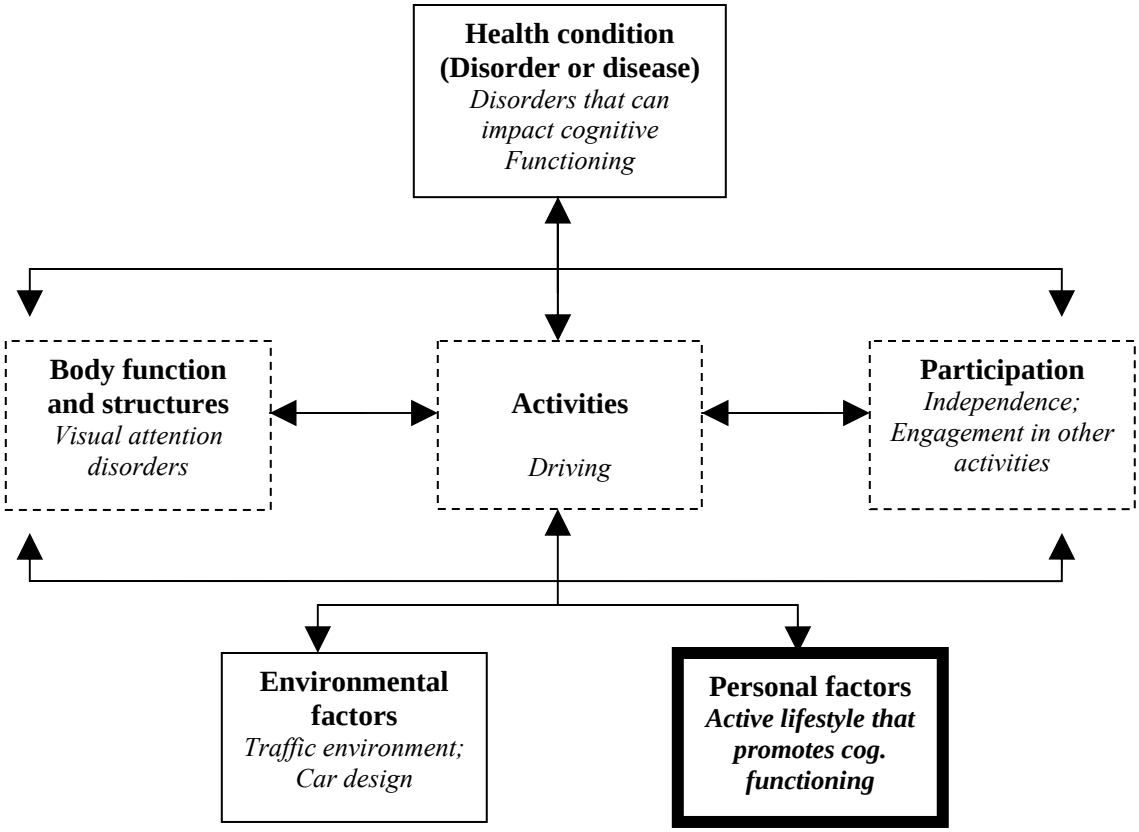


Figure 1-1. Conceptual Framework for the World Health Organization's International Classification of Functioning, Disability and Health (ICF)

CHAPTER 2
LITERATURE REVIEW

Cognitive Training With Older Adults

There has been a growing body of literature over the last three decades suggesting that age-related decline in cognition can be reduced or even reversed through cognitive training. The cognitive abilities trained in the majority of the studies have been the ones that typically show early cognitive declines e.g., speed of processing, memory and reasoning.

Decline in speed of processing is normatively experienced in middle age and decline in memory and reasoning generally begins by the 6th decade of life (Schaie, 1996; Baltes, & Mayer, 1999; Christensen, MacKinnon, Korten, Jorm, Henderson, Jacomb, et al., 1999; Colsher, & Wallace, 1991). Age related declines in these cognitive abilities are on the order of one-quarter of a standard deviation over a four- to seven-year interval in late adulthood (Schaie, 1996; Zelinski, & Burnight, 1997; Hultsch, Hertzog, Dixon, & Small, 1998; Zelinski, & Stewart, 1998; Luszcz, 1998; Sliwinski, & Buschke, 1999).

The magnitude of decline for reasoning reported in the literature has ranged from .22 SD over 7 years to .42 SD over 14 years (Schaie, 1996). Memory changes have been described with estimates including (a) .25 SD over 7 years for semantic lists (Schaie, 1996), (b) half of a standard deviation over 16 years for immediate word recall and 1.00 SD for immediate text recall (Zelinski, & Burnight, 1997), (c) one quarter of a standard deviation over 6 years for immediate word recall (Small, Dixon, Hultsch , & Hertzog, 1999) and (d) .33 SD over 4 years for word recall (Singer, Verhaeghen, Ghisletta, Lindenburger, & Baltes, 2003). Reported speed changes have ranged from .16 SD over 2 years (Ball, & Owsley, 2000) to .25 SD over 4 years (Singer et al, 2002).

Despite the cognitive declines experienced in later life, the research literature suggests that cognitive training may have the potential to reverse such declines. However, it is important to note that cognitive training effects have not been broad and general, but really targeted and narrow. Generally, cognitive gains reported in the literature have been significant and specific to the ability trained (Plemons, Willis, & Baltes, 1978; Willis, Blieszner, & Baltes, 1981; Blieszner, Willis, & Baltes, 1981; Baltes, Dittmann-Kohli, & Kliegl, 1986). ACTIVE is currently the largest clinical trial of cognitive interventions for older adults. It is a six-site trial funded, since 1996, by the National Institute on Aging and the National Institute of Nursing Research. The design of ACTIVE was to use interventions that had proven effective in previous research, that focused on enhancing basic cognitive skills in older adults, and that might improve everyday function in older adults who had not yet experienced functional decline but were at risk for such decline. ACTIVE improved on preceding training research by (a) using a larger (i.e., well powered with 2,802 participants) and more heterogeneous sample, including 27% African American elders, and (b) implementing the training protocol simultaneously at multiple site, to guard against laboratory-specific findings. (Ball, Berch, Helmers, Jobe, Leveck, Marsiske, et al., 2002; Willis, Tennstedt, Marsiske, Ball, Elias, Koepke, et al., 2006).

In the ACTIVE study, participants were randomized to one of four conditions: Reasoning training, Memory training, Useful Field of View (Speed) training, and no-contact control. In all three training groups, participants initially received ten 60-90 minute training sessions, typically administered over five weeks. Initial study results suggested that participants in all three intervention aims experienced immediate significant gains on their targets of training (for reasoning gains averaged .48 SD, for memory they were .26 SD and for Useful Field of View they averaged 1.45 SD), and training group advantages were still observed two years post-

training. (Ball et al., 2002). In a subsequent long-term follow-up, conducted five years after the initial training, there were still persist advantages for trained participants on their targets of training, relative to untrained controls.

The five year net effect of reasoning training was found to be .26 SD; for memory it was .23 SD, and for Useful Field of View (named "Speed of Processing" in study papers), it was .76 SD (Willis, et al., 2006). In addition, in the five year follow-up, participants in all three training groups reported less perceived difficulty with IADLs relative to no-contact controls, a difference which reached significance for the Reasoning group. In addition, in a subgroup of participants who received extra "booster" training (i.e., yielding a total of eighteen 60-90 minute sessions from Year 1 to Year 3 of the study), the extra training (compared to the basic ten-session program) yielded significant improvements on several observed tasks of daily living, as rated by blind raters. Specifically, persons who received booster Reasoning training experienced significantly more gain on measures of Everyday Problem Solving (i.e., the ability to read and understand medication labels, recipes, financial documents, etc.), and persons who received booster Useful Field of View training experienced significantly more gain on measures of Everyday Speed (e.g., ability to quickly and accurately read medication labels, find items in a pantry, look up a phone number in the phone book).

Despite these initially promising results from the ACTIVE trial, built on three decades of successful training research with older adults (LabouvieVief, & Gonda, 1976; Blieszner, Willis & Balter, 1981; Scogin, & Bienias, 1988; Willis & Nesselroade, 1990; Verhaeghen, Marcoen & Goossens, 1992), the more general finding in the literature, across the life span, is that transfer of training to real-world skills is difficult to achieve (Sternberg & Wagner, 1986; Salomon & Perkins, 1989). Even in ACTIVE, transfer effects where small and fairly ephemeral. A broad

conclusion is that studies on the effects of transfer of skills from laboratory to real life situations is scarce.

For older adults, the relative absence of training transfer may be due to the fact that many studies generally exclude persons thought to have incipient dementia, so study participants are not cognitively impaired in the domains of training. In addition it has been reported that IADL performance does not start to decline until the 70's or 80's (Willis, 1996). Taken together, this implies that many older adults may be at "ceiling" in their everyday performance, so measures of everyday functioning may not have enough "room for improvement" to show training effects. More generally, there is an absence of careful taxonomic research linking cognitive domains to everyday functions (Marsiske & Margrett, 2006), and the psychometrics of everyday function measurement often do not produce scores with substantial variance (Velozo, Magalhaes, Pan & Leiter, 1995).

Few studies exist in the research literature that investigated the effect of the transfer of cognitive training to everyday performance. The ACTIVE interventions seem to be a fairly noteworthy late life exception (both within and outside of the ACTIVE study), with a particularly positive pattern noted for Useful Field of View training. UFOV training was found to improve performance of IADL. After participating in 10 1-hour training sessions, participants performed more quickly and accurately on the Timed Instrumental Activities of Daily Living (TIADL) tasks than the control group. The TIADL test emulates everyday tasks such as: looking up phone numbers, counting change and, reading medication bottles (Edwards, Wadley, Myers, Roenker, Cissel & Ball, 2002; Edwards, Wadley, Vance, Wood, Roenker & Ball, 2005). In addition to improvement in TIADL scores, speed of processing training has also been found to transfer to the Road sign test (Roenker, Cissell, Ball, Wadley & Edwards, 2003) and driving

performance (Ball, & Owsley, 2000). These studies support the hypothesis that transfer was only found for the specific cognitive measure being trained. Owsley, Sloane, McGwin and Ball (2002) also investigated which cognitive abilities were independently associated with the time required by older adults to complete IADLs. Results showed that only processing speed was independently associated with TIADL scores: those individuals with slower processing speeds were more likely to require longer times to complete everyday tasks.

These studies support the contention that, among all the cognitive skills usually studied in gerontology research (reasoning, memory and, useful field of view), UFOV training has shown to be the most successful in showing training effects that transfer to everyday activities. The Useful Field of View concept and test are described in greater detail in the next section.

Useful Field of View (UFOV) Test

The UFOV is a measure of speed of processing and visual attention. Visual attention is defined as the area in which information can be acquired within one eye fixation (Ball, Beard, Roenker, Miller, & Griggs, 1988). It is also used as a functional measure of visual processing in older driver performance (Ball, Owsley, Sloane, Roenker, & Bruni, 1993). Deterioration of the UFOV begins at age 20 or younger. This deterioration is characterized by a decrease in the efficiency with which individuals can extract information from a cluttered scene, rather than by a shrinking of the field of view per se. Furthermore, the decrease in efficiency is increased when conditions require the division of attention between central and peripheral tasks (Sekuler, Bennett, & Mamelak, 2000).

The UFOV test was developed by investigators from Alabama and Western Kentucky (UFOV® users guide®). The UFOV test is divided into four subtests that assess speed of visual processing under increasingly complex task demands. Using both eyes, the examinee must detect, identify and localize briefly presented targets.

The first subtest ("Speed") consists of identification of a target presented in a centrally located box (figure 2-1). In the beginning of the test, a white box containing an icon of a car is presented on a stationary display. After the participant receives the instruction to examine the target, he or she touches the continue button and a second screen appears. The participant is then asked to select the target that had been presented on the previous screen (in this case, a car). The next screen introduces the truck icon. As in the previous instructions, the participant is asked to select the target presented in the previous screen (in this case the truck). After these introduction screens, the participant has four trials to practice. The participant can guess, without penalty. There is no feedback with responses throughout the test. Practice continues until the participant scores 3 out of 4 correct on a single practice trial. The length of the stimulus presentation in milliseconds is automatically adjusted for each participant. After two correct responses, presentation time is shortened. However, if the response is incorrect, presentation time will increase. The process of tracking the perceptual thresholds is continued until a stable estimate of the presentation time needed for the respondent to achieve 75% of trials correct is calculated. The minimum (best score) for each test is 16ms; the maximum score is 500ms.

The second subtest is labeled Divided Attention (Figure 2-2). In this case, the participant is asked to identify the centrally presented object and locate a simultaneously presented car displayed in the periphery. A central box, along with a series of 8 boxes attached with radial spokes is numbered from 1 to 8 in a clockwise direction.

Presentation time varies according to the accuracy of the participant, and the subtest continues until a stable measure of the threshold is determined. Again, the 75% correct threshold for correct performance is calculated.

The third subtest is Selective Attention (Figure 2-3). This subtest is identical to subtest 2 except that the target displayed in the periphery (which is always a car) is embedded in a field of 47 triangles or distracters.

The fourth subtest is a modified selective attention subtest, named Same-Different, with two icons in the center of the screen (inside the white box) (Figure 2-4). In this subtest, the examinee is presented with two objects inside the white box in the center of the screen. The examinees have to distinguish if the two objects are the same (two cars or two trucks) or different (a car and a truck). There is also a target in the periphery in a clustered scene.

The UFOV measure has been widely used in clinical and rehabilitation settings and normative UFOV data to adjust performance comparisons across demographically-similar elders has been developed (Edwards et al, 2006) The UFOV has also been widely used in research designed to examine driving performance with older adults and it is the primary outcome of the present study but other outcomes have been investigated and will be described bellow.

Driving Performance Tests

Three other outcome measures are commonly used in studies on driving performance: accident frequency, driving simulator, and road test. The use of each of these variables has advantages and disadvantages.

Accident frequency - This outcome can be measured either by self-report or state report. State report of accident frequency has an advantage over self-report because all licensed drivers have accident records in a standardized format. In addition, state reports include more detailed information about the accident (e.g., road type, time of a day, location) (Owsley et al., 1991). The disadvantages of these state reports are: underreporting of accidents are common and can occur either because of the person or because of the state police. Vehicle accidents can also be caused by factors that are not intrinsic to the driver (e.g., poor mechanical conditions of the car,

weather) (Ball et al., 1991). In addition, accidents are rare events. Owsley et al. (1991), compared self-report police accidents (accidents where the police were at the scene, as indicated by the Driving Habit Questionnaire) with state record accidents (number of accidents on the state record), and found that the number of state record accidents and self-report police accidents did not match. Both types of reports were expected to be related because in Alabama (where the study was conducted), police are required to submit written accident reports to the state every time they go the scene of an accident.

Raedt and Ponjaert-Kristoffersen (2000) used two outcome measures to identify cognitive factors and driving problems in older adults: accident frequency and road performance. While cognitive tests accounted for 64 percent of the variance of the scores on the road performance, cognitive tests accounted for only 19 percent of the variance of the scores on accident frequency.

On-road driving performance - On-road driving performance, when used as an outcome measure for driving research, has the great advantage of measuring one's ability in a real-life situation. Although on-road performance seems to be one of the best outcome measures to measure driving performance, it has some drawbacks. First, there is no control over the environment and the stimulus presented to the participants, which makes it difficult to generalize conclusions. Second, when two or more evaluators take part in the study, inter-rater reliability should be set (Roneker et al, 2003), otherwise data might be compromised. Third, participants can make mistakes because of the pressure of being tested, and they might also not be familiar with the car. On-road tests are usually very expensive.

Driving simulator – An alternative to on-road measures is the driving simulator. In a simulator, the environment can be totally controlled, the same scenarios can be used for every participant and the availability of low cost simulators is also increasing. However, the use of a

simulator has some disadvantages including high cost and possible simulator sickness among participants (Mourant & Thattacheny, 2000). Participants do not have the same experience as a real life situation. However, simulation has a great advantage— it provides a more controlled testing situation. For this reason, and because a simulator was available for use in this study, this was the outcome measure used. Simulator driving performance in this study will be measured by brake reaction distance, lane maintenance and accuracy.

Studies Using Driving Simulator Outcomes

The use of a driving simulator either to educate (Fisher, Laurie, Glasser, Connerney, Pollatsek, Duffy et al., 2002) or train (Dorn & Barker, 2005) the general population is found in the literature. Driving simulators have also been useful to investigate the safety of display positions while driving (Wittmann, Kiss, Gugg, Steffen, Fink, Pöppel et al., 2006) with study participants providing feedback (Donmez, Boyle & Lee, 2007). Another area in which driving simulators have been gaining attention is to measure driving performance of older adults. In this situation, driving performance is generally measured by assessing one's reaction time using different tasks in the simulator. Ronker et. al (2003) measured reaction time in a simulator using a light display located on the top panel of the driver's unit. Participants were instructed to brake as quickly as possible when the two red lights were illuminated. In another experiment, the participants at a distance of 5.8 meters viewed a narrated film, the stimuli were road signs, with and without a red slash through them. Participants were instructed to react only to signs without a red slash. In another study, Lee, Lee and Cameron (2003), used a driving simulator to assess visual attention skills by participant's reaction time. Reaction time was measured by displaying two red diamond-shaped images at the top corners of the monitor screen, which changed to red triangles after every 700 yards of simulated driving. Participants were supposed to engage the turn signal whenever the triangles image appeared on the screen. The validation of a laboratory-

based driving simulator in measuring on-road driving performance has been supported by the literature (Lee, Cameron & Lee, 2003).

Lee and Lee (2005) used a driving simulator to determine which simulated driving tasks can be used to identify older drivers at risk of traffic violations. The simulator was used to assess 10 driving tasks specifically for testing older adults. The driving tasks consisted of: rule compliance, traffic sign compliance, driving speed, use of indicator, decision and judgment, speed compliance, visual attention task, working memory, multi-tasks, and road use obligation. The simulator computer automatically measured the first five tasks whereas a laboratory technician collected the remaining data. Recently, researchers from the University of Florida used a driving simulator to replicate actual road locations. In this study participants drove through the same scenario on the road and in the replicated scenario in the simulator (Shechtman, Classen, Stephens, Bendixen, Belchior, Sandhu, et al., 2007). In this study the simulator's controls were integrated with an actual vehicle which improved the driving experience.

As has been discussed, the driving simulator has been extensively used in research for different tasks, however, standardized tests to measure the same constructs are still missing from the literature. The goal of the present study is to measure visual attention in a simulator. Visual attention will be measured by brake reaction distance but will use tasks not mentioned in previous literature. The next chapter has more details about this measure. The next section will discuss specific interventions that might have the chance to improved scores on either useful field of view and driving simulator.

UFOV Training With Older Adults

UFOV was one of three abilities trained in the NIA-funded ACTIVE trial (see above). In ACTIVE, with a total sample of 2,802 at six sites throughout the US, 25% of participants were randomized to receive UFOV training (other groups received training in reasoning, memory, or

no contact). The content of training was identical to that used in this study. Participants in this condition received 10 sessions (60-90 minutes each). Posttest assessments were conducted immediately, and 1, 2, 3 and 5 years post-training. Immediately after training, on the UFOV test, the pre-post improvement of UFOV-trained participants was 1.45 SD higher than that of untraining controls (Ball et al). Moreover, five years later, the UFOV performance advantage of UFOV-trained participants was still .75 SD greater than untrained controls (Willis et al).

Speed of processing training not only appears to improve processing speed, but also transferred to certain everyday functions, as indicated by improved performance on Timed IADL (Edwards et al, 2005). In ACTIVE, there was less evidence of transfer to real-world functions from the basic 10-session training program. However, a subset of 50% of UFOV-trained participants received up to eight additional booster training sessions (four 12-months after initial training, and four 36-months after initial training). For boosted participants, Willis et al (2006) found that, five years post-training, performance on observed tasks of everyday speed (e.g., speed and accuracy of reading medication labels, finding items in a pantry, looking up numbers in a phone book) was significantly higher than that of participants who received only the basic ten sessions. This seems to strongly argue for extended training and greater training dosages.

Roenker et al (2003) evaluated the effect of UFOV training and simulator training on UFOV test performance and simulator driving performance. Participants were randomized into a speed of processing training group, traditional driver training program performed in a driving simulator, and a low risk control group. The UFOV test consisted of the same test described in previous section and for simulator measure, participants reaction time was assessed. It was found that speed of processing training, but not simulator training improved UFOV scores and had fewer dangerous maneuvers during driving evaluation.

In addition to the cognitive benefits of speed of processing training, a recent study found that speed of processing training protects against extensive clinically relevant decline in health-related quality of life (HRQoL). HRQoL was measured using the eight item Short-Form 36 scale (Wolinsky, Unverzagt, & Smith, 2006).

Video Game Training of Cognition

Video games have become a large form of entertainment in the American society and the average age of video game players also has been increasing. Therefore, researchers are spending more time investigating the effects of video game play on behavior and the brain. Research on video game play goes back to the early 1980's. The earliest studies on the effect of video games investigated the effect of video game on visuo-motor coordination (Griffith, Voloschin, Gibb, & Bailey, 1983), reaction time (Orosy-Fildes, & Allan, 1989; Yuji, 1996) and spatial skills (Dorval, & Pepin, 1986; Gagnon, 1985). Studies not only addressed theoretical findings but also the practical implications of playing video game. Researchers were interested in investigating if the decline in cognitive skills in late life could be improved or even reversed by using video game training. One study found that playing a game called "Crystal Castle" for two months (1 hour of training per week) improved both eye-hand coordination and verbal knowledge in a group of older adults. In addition, participants of this study reported being more careful in the performance of activities of daily living (Drew, & Waters, 1986).

Another study investigated the effects of playing Pac Man and Donkey Kong. This study explored the performance of older adults on speeded tasks. Participants played these games for seven weeks (for at least two hours a week). It was found that the experimental group average time dropped 25 milliseconds (Clark, Lanphear, & Riddick, 1987). Drews and Waters (1986) examined the abilities of video game playing to improve perceptual-motor skills and cognitive

functioning. Clark et al., (1987) examined the possibility that the slowdown in performance among the elderly could be reversed through the use of video games.

Recently researchers have been investigating the use of video game playing in the training of laparoscopic surgeons. It has been suggested that video game play may improve laparoscopic skills (Enochsson, Isaksson, Tour, Kjellin, Hedman, Wredmark, et al., 2004; Rosenberg, Landsittel, & Averch, 2005; Stefanidis, Korndorffer, Dunne, Black, Sierra, Touchard, et al., 2006). Because laparoscopic surgery uses very small incisions, adequate eye-hand coordination is required and, studies suggest that video game players increase the efficiency of screening and decrease the duration of examination. Video game playing has also practical implications in the military. Cadets trained on video games had a higher flight performance than their untrained peers (Gopher, Weil, & Bareket, 1994)

The effects of video game playing on visual attention has been the focus of more recent studies. Although these studies were not conducted with older adults, they have promising findings that might be further replicated in the older population. Studies found that video game playing increases efficiency in dividing attention (Greenfield, DeWinstanley, Kilpatrick, & Kaye, 1994). A similar measure to The Useful Field of View (UFOV) test was used to assess the efficiency in which participants distributed their attention. Relative to non video game players (NVGPs), video game players (VGPs) relied on similar types of visual processing strategies but possessed faster stimulus-response mappings in visual attention tasks (Castel, Pratt, & Drummond, 2005). Researchers have been also interested in the neurochemical consequences of video game playing. Using a form of brain imaging (Positron Emission Tomography or PET) researchers observed a large increase in the amount of dopamine released in the brain, in particular areas thought to control reward and learning. Dopamine may be important in the

modification of the brain following perceptual training, leading to faster and more widespread learning (Koepp, Gunn, Lawrence, Cunningham, Dagher, Jones, et al., 1998). Another study investigated whether 30 minutes of playing a video game would result in differences in brain functioning. It was found that video game playing provided more emotional arousal activation (Wang, Mathews, Kalnin, Mosier, Dunn, & Kronenberger, 2006).

The idea that playing a computer-based game can improve or even reverse the effects of aging related decline has caught the attention of the popular news media. Video games that claim to improve or even reverse the effects of aging can be found in the market. Even though these products may be effective, there is little scientific evidence behind it. One of these video games is Brain Age, developed by Nintendo. It claims to be a way to exercise your brain giving the workout it needs such as arithmetic, memory and reading aloud. It was developed by a Japanese neuroscientist (Kawashima, Okita, Yamazaki, Tajima, Yoshida, Taira, et al., 2005) based, in part, on previous studies in which the cognitive functioning of patients with Alzheimer's disease improved after 6 months of (paper and pencil, tutor-guided) training on arithmetic and reading skills. However, there is no research developed on the effect of this particular game. Another example is a product named Positscience. It consists of a series of computer-based exercises that have the goal of boosting a variety of brain functions. The Positscience program it consists of 40 one-hour sessions. Some positive scientific evidence for enhancement in cognitive skill has been reported (Mahncke, Connor, Appleman, Ahsanuddin, Hardy, Wood, et al., 2006), although long-term follow-up and training transfer have not yet been reported in sizable, diverse controlled trials. Although there might be products on the market that can promote cognitive skills in older adults, more research needs to investigate its effect. This current study examines the effect of

video games, which are widely available, and might have benefits in terms improving cognitive skills in older adults.

Video Game Studies Conducted by Green and Bavelier

Green and Bavelier (2003) showed that playing a first person action video game improved a range of visual skills in undergraduate students. In their assessment battery was a measure that was designed to capture aspects of Useful Field of View; this task differed from the Alabama version, and focused mostly on peripheral target detection (without the central foveal task). A first substudy compared students with extensive experience playing action video games to novices, and found that experienced games outperformed participants without experience on multiple visual attention tasks. In a second training study, novices were randomized to two conditions (ten hours of Medal of Honor (MOH), an action video game, or ten hours of Tetris, conceptualized as a placebo control). This substudy found that non-experienced players who MOH-trained in the study for 10 1-hour sessions showed significantly greater improvement in visual attention skills, including a UFOV-type task, than Tetris controls. The current study was a replication and extension of Green et al.'s, visual attention study, extending the prior study by using an older sample, a widely used measure of Useful Field of View as the proximal outcome, and by examining transfer to driving-simulator based measures of driving performance.

Playing a first person action video game improves a range of visual skills (Green & Bavelier, 2006a) such as: "the overall capacity of the attentional system (the number of items that can be attended), the ability to effectively deploy attention over space and the temporal resolution of attention (the efficiency with which attention acts over time)". Participants in this study underwent training for an hour per day for 10 days. The experimental group played the game Medal of Honor: Allied Assault. This game simulates Second World War combat situations, has a relatively simple interface, uses first-person point of view and requires effective

monitoring of the whole visual field. The control group played Tetris, chosen to control for visuo-motor coordination. In addition to the effects on the spatial and temporal aspects of visual attention, playing action video games also enhances the number of objects that can be apprehended and it is suggested that this enhancement is mediated by changes in visual short-term memory skills (Green & Bavelier, 2006a).

Green and Bavelier (2006b) also investigated the characteristics of the games that contributed to enhancement of visual attention. Participants with little or no experience with video games were recruited to participate in the study and they were selected to participate in different games. Participants received training for twelve hours and their performance on two visual attention measures were assessed: 1) the attentional blink measure, designed to measure the temporal resolution of visual attention and, 2) the multiple object tracking task, designed to measure the number of moving objects that can be attended simultaneously over a period of several seconds. Several games were used in the study. The experimental group played Unreal Tournment. This is a first person shooter game and requires effective monitoring of the entire visual field. The second group played the America's Army, a free access game created by the US Army. This game is also a first person shooter, but it differs from the experimental game because the participants go through a lot of training exercises which reduces the time spent in a battle. The game also emphasizes strategy and teamwork. The third group played Harry Potter: Quidditch World Cup. This game also has the visual attention component but it also requires the completion of training exercises which took time away from actual playing of the main gain. The fourth group played Tetris, and this game was selected to control for the effect of improved visio-motor coordination. The fifth group underwent rhythmicity training designed by Interactive Metronome Inc. and this training relies on accurate timing. Results showed that the experimental

group (Unreal Tournament) was the only one with significant changes in scores in the outcome measures of attentional blink and multiple object tracking. The authors proposed game characteristics that might improve visual attention, including: the need to be fast and unpredictable stimuli. The games must, have unexpected events that require a fast and accurate response from the player and games that do not encourage the use of passive strategies which might reduce attentional load.

In a more recent study, Green and Bavelier (2007) investigated mechanisms underlying improvement in visual attention. They found that video game playing can alter fundamental characteristics of the visual system such as the spatial resolution of visual processing across the visual field. The spatial resolution of visual attention was measured by the smallest distance a distracter could be from a target without compromising target identification. Results showed that, compared with a non-video game player, an action video game player could tolerate smaller target-distracter distances. Similar effects were also observed in non video game players who underwent training in action video games. The authors concluded that there is a causal relationship between video game playing and augmented spatial resolution.

Although there are several studies that show improvement in visual attention, these studies were conducted with young participants. There is no investigation of the effect of video game training to improve visual attention in older adults. Given the importance of visual attention skill for driving, and given the importance of driving for older adults and the lack of visual attention training, it is important to investigate possible interventions. It is also necessary to investigate the acceptance of these games by the older population and their engagement in the games.

Engagement

Engagement in the activity will greatly influence the video game experience. In addition, engagement in meaningful activities can increase quality of life for many individuals (Suto,

1998), contribute to life satisfaction in later life (Kelly, Steinkamp, & Kelly, 1987), and reduce mortality rates (Lennartsson, & Silverstein, 2001).

Engagement in leisure activities can be conceptualized via Flow theory (Csikszentmihalyi, 1975). Flow can be said to occur when people are able to meet the challenges of their environment with appropriate skills and accordingly feel a sense of well-being, a sense of mastery, and a heightened sense of self-esteem (Csikszentmihalyi, 1990). Flow is also characterized by a deep sense of enjoyment. The enjoyment is not simply the result of satisfying a need, but occurs when a person achieves something unexpected which has a sense of novelty (Csikszentmihalyi, 1990). Csikszentmihalyi describes flow as happening most easily in sports, games, and hobbies because these activities are created in a way to facilitate flow.

According to Flow theory research, when a person perceives a challenge (an intrinsic demand experienced when engaged in an activity) as being greater than his or her perceived skills (the individual's perception of his or her capacity to meet the demands of the activity), the person experiences worry and anxiety. On the other hand, if the person perceives his or her skills as being greater than the challenge at hand, he or she will experience boredom and apathy (Massimini, Csikzentmihalyi & Massimo, 1987). The goal is to find a match between challenges and skills in order to have an optimal experience.

Farrow and Reid (2004) found that older adults experienced flow when participating in a virtual reality rehabilitation program. Participants who participated in this program described a sense of involvement, enjoyment, and control over the environment, which contributed to the flow experience.

Because video games are thought to represent an innovative approach for training visual attention in older adults, it is also important to investigate participants' engagement with this

technology. Such engagement may serve as an indicator of potential compliance with video game training, and speaks more generally to the acceptability and motivation potential that such training offers.

Current Thinking About Training With Older Adults/Real World/Cognitive Reserve

This study also falls within the growing body of literature that suggests that there may be an association between participation in cognitively stimulating everyday activities and one's cognitive status. Studies suggest that participation in common cognitive activities such as: playing games such as cards, crossword puzzles, checkers and other puzzles is associated with reduced risk for Alzheimer's disease (Wilson, Mendes de Leon, Barnes, Schneider, Bienias, Evans, & Bennett, 2002). In addition, it seems to be have a protective effect against dementia in people who maintain intellectual and social engagement through participation in everyday activities (Scarmeas, Levy, & Tang, 2001). Other studies have examined the effect of engagement in mental, physical and social activities on non-demented individuals. Researchers often assess activity level using self-report measures of the amount of time spent in a range of specific activities (Mackinnon, Christensen, Hofer, Korten, & Jorm, 2003; Kramer, Bherer, Colcombe, Dong, & Greenough, 2004; Milgram, Siwak-Trapp, Araujo, & Head, 2006). After controlling for sensory functions Newson (2005) found that activity was a significant predictor of current level of speed, picture naming, incident recall, and verbal fluency and of cognitive changes in speed, picture naming and incident recall (Newson, & Kemps, 2005).

Ghisletta (2006) found that increased media (e.g., listening to the radio, watching television) and leisure activity engagement (e.g., playing games, doing crossword puzzles) may lessen decline in perceptual speed but not in verbal fluency or performance (Ghisletta, Bickel, & Lövdén, 2006). Wilson (2003) constructed a measure of lifelong participation in cognitive activities (Fratiglioni, Paillard-Borg, & Winblad, 2004). Participants were rated according to

how often they participated in common cognitive activities at the age of 6, 12, 18, 40 and current age. This study found that more frequent cognitive activity was related to better perceptual speed, visuo-spatial ability and semantic memory but not to episodic memory or working memory. Scarmeas (2003) discussed the importance of a lifestyle change that would supply a reserve that would allow individuals to cope longer before AD is manifested (Scarmeas, & Stern, 2003).

Fratiglioni (2004) argues that the three lifestyle components described above (mental, physical and social), have a common pathway .Research from both animal (Winocur, 1988; Pham, Winblad, Granholm, & Mohammed, 2002) and human studies suggest that there is a developmental neuron plasticity with regard to cognition and that cognitive stimulation in the environment is an important predictor of enhancement and maintenance of cognitive functioning. One such environmental factor that has received a lot of attention by researchers is an engaged lifestyle. It has been proposed that older adults who are engaged in a more active lifestyle can promote their cognitive functioning. Hence, frequent use of challenging mental tasks would be associated with a relatively higher level of cognitive reserve (Hultsch, Hertzog, Small, & Dixon, 1999). Although there is cognitive and neural plasticity across the adult life span, there is still the potential for improvement (Jones, Nyberg, Sandblom, Stigsdotter Neely, Ingvar, Magnus Petersson, & Backman, 2006).

Although most of these studies are correlational in nature, experimental research, as described in the previous sections support such findings and gives more evidence for a causal relationship between cognitive training and improvement in cognitive skills.

Although the body of research on the effects of participating in cognitively stimulating activities and the improvement in cognition is broad and leads to optimistic conclusions, to date

there are not many programs designed to provide opportunities for mental stimulation in later life. Therefore, identifying techniques to enhance cognitive function in older adults are of utmost importance. Few examples of cognitive training programs are reported in the literature. One such program is the Experience Corps, which is a social model for health promotion in older adults (Fried, Carlson, Freedman, Frick, Glass, Hill, et al., 2004; Glass, Freedman, Carlson, Hill, Frick, Ialongo, et al., 2004). This program found some short-term improvement in cognitive, social and physical factors. In this program, older volunteers were place in elementary schools in roles designed to meet school needs. Participants spent 15 hours a week in the school for approximately 9 months. Further studies are necessary to investigate more specific cognitive measures.

Virtual reality has also been used as a tool for cognitive training (more precisely, cognitive rehabilitation) research. Weiss (2003) investigated the effects of virtual reality in training stroke patients with unilateral neglect in relearning how to cross a street independently (Weiss, Naveh, & Katz, 2003). Gourlay (2000), used virtual reality technology to help cognitively impaired individuals to relearn important daily living skills (Gourlay, Lun, & Lee, 2000). Lee (2003) developed a virtual supermarket to assess and train cognitive abilities in ADL (Lee, Ku, Cho, Hahn, Kim, Lee, Kang, Kim, Yu, Wiederhold, Wiederhold, & Kim, 2003).

Importance of the Study

Driving is one of the most important activities in late life because it facilitates engagement in several other activities. Driving is a very complex task and can represent a challenge to older adults due to the normal declines associated with aging. Visual attention is one of the main cognitive functions related to driving, and research has shown that this cognitive skill can be improved with training. However, there are not many options for visual attention training

available. This study explored a potentially new form of training of visual attention, which is the video game.

The magnitude of video game playing training effects might not correspond that of the UFOV® training, but video game playing has the advantage of being more available and perhaps more enjoyable. In addition, video game training can be done at home, which in turn might lead to an increase in training time. The increase in training time might enhance training effect and, video game training can be compared to UFOV training.

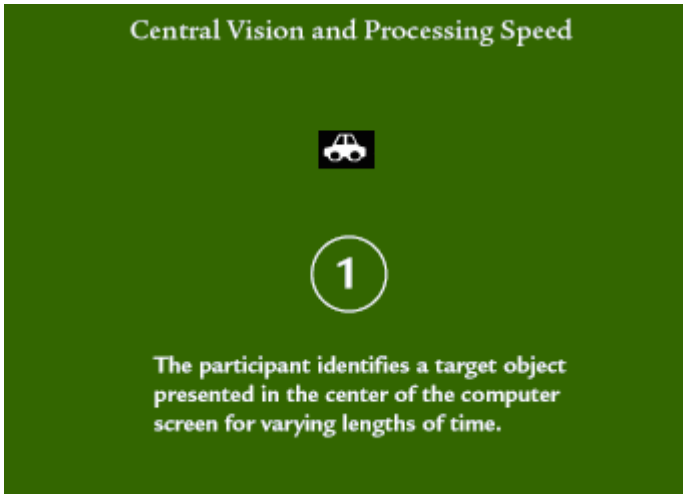


Figure 2-1. – Processing speed subtask

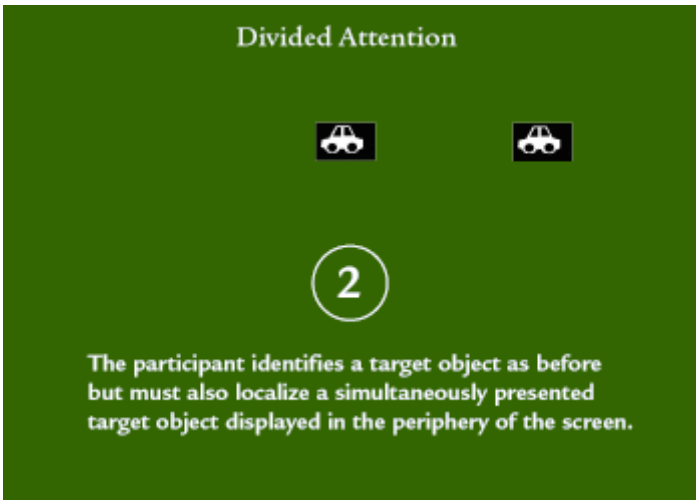


Figure 2-2. Divided attention subtask

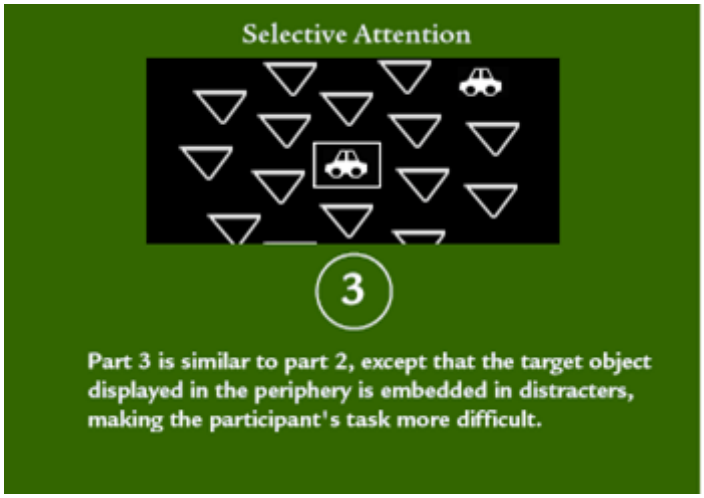


Figure 2-3. Selective attention subtask

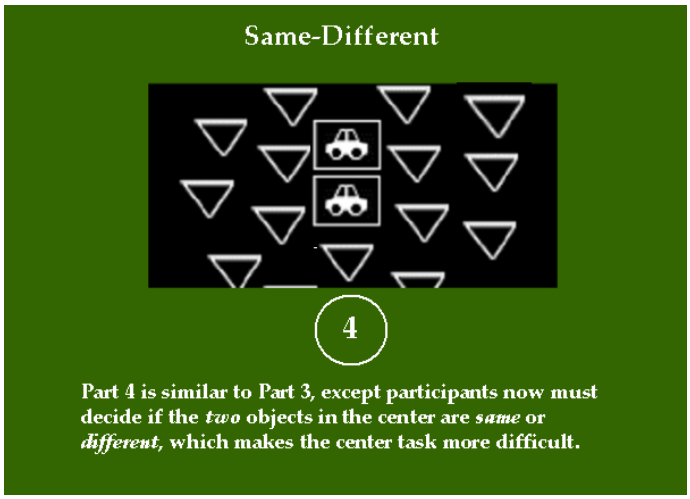


Figure 2-4. Same different subtask

CHAPTER 3
MATERIALS AND METHODS

Overall Procedure

Participants were recruited by phone calls, by mail and through flyers that were distributed in the community. Potential participants were pre-screened by telephone and to eligibility criteria should be met in order for them to be scheduled for a baseline assessment (65 or older, current driving, willing to participate in 6 training sessions and no previous experience with video games). The baseline assessment took about 1 hour and a half to be completed. Participants were then randomized to one of three intervention groups (MOH-UFOV-Tetris). Training consisted of 6 training sessions of 90 minutes each. After each training session, participants completed a flow questionnaire to measure their engagement with the training. One week after intervention, participants returned for posttest. A no-contact control group were added to the study after the intervention study was completed, this group were not randomized but were recruited from the same recruitment pool. Participants from the no-contact control group completed pre and posttest within three weeks interval.

Study Design

The current study employed a pretest-posttest control group design. Analytically, the study included one within-person condition (i.e., pretest-posttest) and one between–person condition factor (i.e., four intervention groups). The within–person condition assessed change in performance on several cognitive and non-cognitive measures over time; for three of four groups, this was change pre- and post-intervention. The between-persons condition assessed differences between persons assigned to each of the four treatment conditions. The critical analytic effect of interest in this study, the occasion X group interaction, assessed whether change differed by intervention group, such that members of some groups experienced more

improvement than others. For individuals randomly assigned to the three intervention groups, between the pretest and posttest they participated in 6 training sessions of approximately 90 minutes duration. Participants from the no-contact control group received a pretest, followed by a posttest three weeks later.

The four interventions used in the current study were: 1) Medal of Honor (MOH), which is a "first person shooter" video game; 2) Useful Field of View (UFOV), which is an adaptive, customized visual attention training program using iterative training rules and a touch screen computer and 3) Tetris , which is an arcade video game, and which was here construed as a placebo control condition, and 4) a no-contact control group. This fourth group did not receive any intervention. Detailed information for each training intervention is provided below. A schematic diagram of the study design is shown in figure 3-1.

Study Specific Aims and Hypothesis

The purpose of this study is to investigate the efficacy of using an action video game (Medal of Honor; MOH) to improve the visual attention (UFOV) performance of older adults. The study will also investigate the effects of MOH training on a "real-world" outcome of older adults' simulated driving performance.

The **specific aims** of this study are:

Aim 1 - To investigate whether UFOV performance can be improved by training via a first-person action video game (MOH) and to compare such training to: (a) "gold- standard" touch screen based UFOV training, b) an alternative video game (Tetris) construed as a placebo control and c) no-contact pre post only control group.

Hypothesis: The UFOV training protocol has been found to be effective in training the visual attention of older individuals. We expect participants receiving the classic UFOV training to experience greater performance improvements than all other participants; we expect those

receiving MOH training to experience more visual attention improvements than either the placebo control (Tetris) or no-contact control conditions. This hypothesis can be illustrated with the following diagram (Figure 3-2):

Aim 2 - To investigate if video game training benefits also transfer to simulated driving performance – The ultimate goal of this study is to investigate if visual attention training can be transferred to a real life situation, which will be measured by driving performance in a simulator. Simulator driving performance will be measured by three dependent variables: (a) Brake reaction distance after participants perceive an object (a dog) in or near the roadway; (b) Lane maintenance as participants approach and pass the dogs; and (c) Accuracy of detection of dogs in/near the roadway (i.e., do participants brake for the dog, or do they pass it by without braking).

Hypothesis: The UFOV training group will obtain better scores than the MOH video game groups, MOH group will obtain higher scores than the two control groups (Tetris, no-contact). This hypothesis can be illustrated with the following diagram (Figure 3-3):

Aim 3 – To investigate participants' engagement, or perceived Flow, through the course of video game or UFOV training. Degree of engagement in the training experience may serve as an indicator of potential compliance with and effort/motivation in training. Flow was assessed at the end of each training session in which participants engaged. Thus, it was assessed only for participants in the three training conditions, and it was not assessed in the pretest-posttest design, but in each of the six training sessions.

Hypothesis: Participants who received video game training (MOH or Tetris) will experience a greater increase in Flow scores as compared to participants who received UFOV training. For the video game players, we expected that the improvement in Flow would occur

due to increasing match between the challenges of the game (MOH, Tetris) and participants' skill level. In addition, the game itself is entertaining and enjoyable. On the other hand, UFOV is less entertaining and enjoyable, and it also provides participants with less explicit feedback about their performance improvements. Thus, we did not expect Flow improvements in UFOV training.

Aim 4 – To explore participants' opinion about game design – This is a consumer-oriented aim and this data was intended to provide information that may assist in future improvements of game design, so that games are more responsive to the needs of older adults.

Participants

Inclusion and Exclusion Criteria

Inclusion criteria for this study included: a) 65 years or older, b) no previous experience with video games, because previous experience with video games can mask the real effects of training, c) be a current driver, as driving performance will be tested on a simulator, the participant must be a current driver d) MMSE of 24 or higher, e) be willing to participate in 6 training sessions, f) visual acuity of 20/70, visual acuity tests were used because eye sensory function plays an important role in UFOV test performance. In addition, training effects could be compromised by a lack of visual acuity. Participants with scores of 200 or lower in the UFOV (accumulated scores) were excluded from the study because they would not have room for improvement.

Recruitment

Participants were recruited by phone calls, by mail and through flyers that were distributed in the community. Participants from 3 recruitment pools were contacted. Individuals from the Rehabilitation Engineering Research Center (RERC) and the National Older Driver Research and Training Center (NODRTC) were contacted by telephone, and individuals from the Institute

on Aging (IOA) registry first received a letter by mail with study information and were asked to contact study staff if they were interested in more information about the study. Out of 58 participants who completed the study, 7 participants were recruited from the RERC recruitment pool, 36 were recruited by mail from the IoA registry, 10 responded to a press release in the Senior Times Magazine, 2 were referred by friends and 2 were recruited at a townhouse meeting at a senior residential community in Gainesville. Participants received $10.00 for each visit. A participant who attended baseline testing, six training sessions, and the post-training testing received $80.00. Participants from the no-contact control group received a maximum of $20.00 (pre and posttest).

Sample Characteristics

A total of 70 participants completed the pretest battery for this study. All participants who completed the pretest battery were then eligible to be randomized to a treatment condition. A total of 12 (17%) participants withdrew from the study; 9 of these participants withdrew prior to randomization because the training schedule could not accommodate their personal schedule. Three participants (one of each training group) withdrew post-randomization, during the training intervention. Two of those participants were employed and their schedules were in conflict with the training schedule and one of them withdrew due to perceived boredom of the training task. All participants from the no-contact control group appeared at both the pre- and post-test assessments. A total of 58 participants completed the study. In general, participants were young-old, college educated, they were equally distributed across gender and all participants were Caucasian, except one Asian participant who withdraw before random assignment.

Testing Design and Procedure

Prior to in-person contact with the study, potential participants were first pre-screened via telephone. In the phone interview, four inclusion criteria were assessed: a) 65 years or older, b)

current driver, c) no previous experience with video games and d) be willing to participate in 6 training sessions. If these requirements were met, participants were scheduled for a baseline assessment.

Baseline Assessment

During the intake session, participants were informed about the research purposes and procedures, and (if willing) completed an informed consent form. After consenting, the participants took two more tests to determine their eligibility: 1) Mini Mental State Examination (MMSE), in which participants were required to score 24 or higher; and 2) a visual acuity test, in which participants were required to have a score of 20/70 or better. After administration of these tests, eligible participants were administered the Useful Field of View (UFOV) test. If a participant had a score of 200 or higher in this test, participants completed the remaining baseline measures. These included a driving simulator test, a memory test and questionnaires regarding (a) demographics, (b) depression; and (c) hearing impairment. The duration of the baseline session was approximately 1.5 hours, and participants could take as many breaks as they needed. After the baseline assessment was completed, participants were randomized, and scheduled for their 6 training sessions. Participants from the no-contact control group returned three weeks after baseline assessment for a posttest.

Random Assignment

After baseline assessment participants who were determined to have met the inclusion criteria for the study, were randomized into one of <u>three</u> groups (Medal of Honor, UFOV, or Tetris). Randomization occurred in "triplets" (i.e., after a group of three participants had met eligibility, one participant was assigned to each of the three groups). After the conclusion of the interventions for the three groups, and after interim data analyses had been conducted, a fourth non-equivalent control group was recruited. This separate group of participants was recruited for

the sole purpose of pretesting and posttesting (without intervention) and was not randomized to this condition. More detail on the rationale for this group is provided below. Although the no-contact control group was recruited later in the study and was not randomized, participants came from the same recruitment sources as the experimental participants.

Rationale for the Inclusion of a No-Contact Control Group

Interim data analyses from the three intervention groups revealed that there were improvements in the primary outcome measure (UFOV) for all three treatment groups (MOH, UFOV, Tetris). The improvements for the Tetris group (in particular) were not expected (on the basis of the earlier Green and Bavelier group, who conceptualized Tetris as a kind of placebo control condition). Thus, it was difficult (conceptually) to determine whether the improvements in the two video game groups (MOH and tetris) were due to playing these games, or whether they reflected simple practice effects due to pretesting and posttesting. A prior intervention study (ACTIVE, Ball et a., 2002) had shown that no-contact control participants experienced about as much pre-post gain as shown by the videogame groups in this study, which suggested that the observed improvement might be due to testing alone.

The decision was made, within the context of the current population, to verify that simple pretest-posttest improvements in participants who received no intervention would, in fact, be as large as those recruited for the two videogame groups. While the late inclusion of such a group would raise concerns of non-equivalence, careful comparisons of the no-contact group to the randomized groups would permit a quantitative characterization of the magnitude of bias, if any. (As the foregoing participants section revealed, the no-contact control group did not differ on any assessed variables from the other groups, at baseline).

To summarize: A no-contact control group was added to the study after the data from the intervention groups was collected. This no-contact group was not randomized but was recruited

from the same recruitment pool from the previous participants. This was necessary to assess the simple effect of taking the pretest-posttest battery twice. Participants took the pre- and posttest about three weeks apart, with no treatment/stimulation/contact between testings. Group comparison analyses for Aims 1 and 2 (see next chapter) include this no-contact group.

Posttest

Within one week of completing the training, participants were asked to come back for a post-testing session. The content of this session was almost identical to that of the initial assessment. Participants were asked to answer some extra opinion questions regarding the design of the games and controllers they used during the training. The posttesting required about one hour and 15 minutes to be completed.

Measure During Intervention

A perceived engagement, or "Flow", questionnaire was administered to the intervention groups after each training session. The measure required about 5 minutes for completion. All measures are described in greater detail in the measures section below.

Training

Overview of Training

In this study, for all training interventions, the intervention was provided in small groups, in six 90 minutes sessions. Participants received two or three training sessions each week. The first group played a first action video game (Medal of Honor). This game was specifically chosen because it was found to be the best game to train visual attention (in college students; Green et al., 2003) in one study. The second group received instruction in Useful Field of View (UFOV). UFOV was chosen because this is the gold standard training and we wanted to compare training effect. The third group, Tetris served as a control group, and followed the same training

procedures of the first group, except they played a “placebo” game (i.e., reported by Green et al. NOT to improve visual attention in college students)

Trainers were undergraduate student assistants who had extensive self-reported experience with action video games. All trainers received instruction in the implementation of the study’s interventions, which were manualized. All undergrad students who worked in this project were trained by the doctoral student. Prior to start of intervention with participants, they spent time playing the game using the manuals that were developed. Then, they practiced training with one another and whenever possible with somebody not familiar with video games. It was important to make sure that the training was standardized and all students used the same procedures with all participants.

Medal of Honor Training

The two video game training conditions (MOH and Tetris) differed from UFOV in not using a computer, but in using a commercially-available video game system instead. The study employed a Sony PlayStation 2, console model 97060 and dual shock 2 analog controller, model 97026. The game was presented on a 19” TV monitor.

In this training, participants were asked to play the "first person shooter" video game Medal of Honor – Rising Sun, first with a tutor and then more independently. The game is made up of multiple missions. In each session, participants were first asked to navigate through a particular on-screen mission (for example, after one’s ship is hit by enemy torpedoes while one is two levels below, one must struggle to reach the ship’s deck, extinguishing fires and assisting crew members along the way; once atop, one must use an artillery gun to discourage combatants’ airplanes, which are dropping bombs on the ship). The missions were broken into step-by-step maneuvers (Appendix A), and the tutor provided participants with complete assistance to navigate the scene. When participants successfully made it through the mission, they were asked

to repeat the mission on their own, drawing on their tutor's help if needed. Once they had mastered a mission on their own, they moved on to the next mission. **This was the main intervention under study; Green & Bavelier (2003), have reported that playing this game boosts visual attention, as assessed with their measures, in young adults.** The remainder of this section describes the training procedure in greater detail.

In session 1, the participants had about 15 minutes of tutoring on the video game, as none of them had previous experience with video games before. The tutor explained to the participants that Medal of Honor is a game based on the Second World War. The tutors explained that MOH is an action game; thus, there would be considerable shooting and some scenes of violence. If at any time participants did not feel comfortable with the game, they were allowed to stop playing. No participant withdrew for this reason. Participants were also asked to take a 5-minute break after 45 minutes of playing.

The participants also learned that the game was divided into missions. It was expected that each participant would be able to complete about 4 missions during the 6 training sessions. In order to finish each mission, several "mission objectives" (that were explained in details during each game) would be completed. A guide with step-by-step instructions for each mission was developed and the participants were expected to follow instructions provided by the manual. Each mission would be completed twice. The first time, a tutor would give step-by-step instructions. Once the participant completed the mission once, they were expected to repeat the mission without much help from the tutor. We expected that by playing each mission twice, the participant would be able to spend more time concentrating on the parts of the game supposed to promote visual learning rather then trying to learn the game.

If participants did not have any further questions about the training, after the tutor's instructions the tutor modeled by playing the game for about 10 minutes and the participants watched them playing. Next, the tutors explained how the controller works and what each button does. This was a brief explanation because a detailed explanation was provided during the first mission, which served as a tutorial. In the first mission, the participants had a chance to practice each button. Figure 3-4 presents the controller used by participants and the description of some of the buttons used to play this game.

Once each button was introduced to the participants during the first mission, they were expected to practice using it until they felt comfortable doing so. The tutor moved forward with the instructions only once the participants successfully completed the task controlled by that button, e.g., use the button to jump over the wires on the floor. Step-by-step instructions were presented through PowerPoint slides on a computer that was placed next to the participants. The trainers would control the speed of the presentation of each PowerPoint slide. The instructions were divided step-by-step (an example is presented on figure 3-5) and at the end of each instruction (or slide), the participants were asked to pause the game before moving forward in the game. This was done, during the learning phase, to reduce all time pressure that might have impaired learning. During the first time the participants played the mission, the tutors were very involved in helping them to finish the missions, but the second time the participants went through the missions, the tutors only helped if required.

Also, each time a new button was introduced to the participants, the instruction was presented in the slides (Figure 3-6). The participants would keep practicing the use of each button until they could perform the task successfully.

The difficulty level increased at each new mission. Mission 1 – Day of Infamy - is designed to learn the basic maneuvers used through the game, such as turn right/left, look up/down, jump, crouch. The game starts in a bunker room. The goal is to leave the room, walk upstairs, and put out a fire. After extinguishing the fire you have to keep moving forward and go up another set of stairs. You will be given a gun and you have to shoot at some enemy planes. This completes the mission. Mission 2 – Pearl Harbor - is a very short mission. It starts on a boat and the only job is to shoot down planes flying through the area. Mission 3 - Fall of the Philippines – starts on a bridge with fires around you. You need to walk out of the bridge, meet some friends and fire on some enemies. Through the mission there are several "mission objectives" that need to be completed in order to keep moving, such as find the cogwheel of a tank and repair it. Once the tank is fixed you should follow it through a village, enemies will be shooting at you and your goal is to search for the enemies in different scenarios, sometimes they are easy to see, sometimes they are hidden. The next mission in the game is the midnight raid on Guadalcanal, but because this scenario happens at night, and the scenes were very dark and hard to see it was skipped. For this study purpose, mission 4 was the Pistol Pete Shutdown – in this mission you have a lot of "mission objectives" to complete, such as releasing some of your teammates being held captive. Through all the missions, participants must continuously visually scan the scenarios because there are enemies who try to shoot at you. The game was set up in a way that the participants would have unlimited ammunition and a have a "bulletproof vest." By using these options, the game was less challenging and the participants could play for a longer time.

Useful Field of View Training

The Useful Field of View training was administered via a computer. A CPU was connected to a 21" ELO touch screen. The training consisted of six 90-minute sessions. This

was a deviation from a published version, which included ten 60-90 minutes sessions (Ball et al., 2000) but which was instituted due to resource constraints (the available time for the researcher and volunteer trainers to complete the study) and participant schedules. The complexity of the UFOV subtests is modified by holding the duration of the display constant and by gradually increasing the complexity of the central task, the peripheral task or both. These modifications allow individuals to practice the task at customized levels of difficulty until mastery is achieved. Training sessions for UFOV have been described in previous research (Edwards, Wadley, Myers, Roenker, Cissell, & Ball, 2002).

This training was adapted from the UFOV training guide from previous studies (Appendix B). In the initial assessment, participants received a preliminary score on the Useful Field of View (UFOV) test (see below for how these scores influenced training decisions). In general, training was started at participants' current skill level, and after they had mastered that level, the challenge increased, either by reducing the amount of time available to perform the task, or by increasing the visual complexity of the display to be studied. **Based on prior literature, this training represented the "gold standard" for improving the visual attention of older adults. It was selected to be used as the reference condition against which the efficacy of video game training could be compared.** The remainder of this section describes the training procedure in greater detail.

In Session 1, training was customized to participants' baseline UFOV performance. As noted below, the UFOV consisted of four subtasks. Due to lower bound timing limits and upper bound time-out programming, possible scores ranged from 16 ms to 500 ms for each subtask.

Subtask 1, Speed: Measures the average presentation time needed for participants to detect whether a centrally presented two-dimensional white object (against a black background) is a *car* or a *truck*, with 75% accuracy.

Subtask 2, Divided Attention: Measures the average presentation time needed for participants to detect whether a centrally presented two-dimensional white object (against a black background) is a car or a truck while simultaneously noting the screen location of a peripherally presented car, with 75% accuracy.

Subtask 3, Selective Attention: Measures the average presentation time needed for participants to detect whether a centrally presented two-dimensional white object (against a black background) is a car or a truck while simultaneously noting the screen location of a peripherally located car that is presented in screen clutter, with 75% accuracy.

Subtask 4, Same Different: Measures the average presentation time needed for participants to detect whether two centrally presented two-dimensional white objects (vertically arrayed, against a black background) are (a) two cars--same; (b) two trucks--same; or (c) a car and a truck--different, while simultaneously noting the screen location of a peripherally located car that is presented in screen clutter, with 75% accuracy.

Customization rules were as follows:

1. If the participant scored greater than 30 ms on the Speed task, they were first trained on Speed. In this case, participants were presented with the Speed task again, and allowed to practice. They continued to practice until their score moved below 30 ms. If participants remained stuck at a "plateau", a simpler center task (not identifying whether the center object was a car or truck, but simply identifying whether an object was present) was selected, until participants achieved a score of 30 ms or faster on this simpler ("presence-absence") center task.

Once participants reached 30 ms or faster, they returned to the "identify (car or truck)" center task until they achieved a score of 30 ms or faster. Finally, before progressing to the next training level, participants moved to the most difficult center task ("same-different", see above), until they achieved a score of 30 ms or faster. At this point, they progressed to the next Divided Attention training track.

2. If the participant was below criterion (30 ms) on the Speed Subtask 1, but above 40 ms on the Divided Attention Subtask 2, training began at this level. (Participants who "graduated" from the Speed training above also progressed next to this training level). Participants moving here from Speed training always started at 200 ms presentation time. Participants moving directly to this level of training had their initial presentation time set to their score in the baseline screening UFOV score, within 40 ms in multiples of 40 ms (i.e., if their baseline screening score on Divided Attention Subtask 2 was 162 ms, the participant would start at 200 ms; if the baseline Divided Attention score was 251, participants would start at 280 ms). In this training, and in all other training tracks, participants would receive a block of 16 trials at the selected speed, with the peripheral object presented at close eccentricity (i.e., close to the center of the screen). Once the participant achieved two consecutive blocks with at least 12-out-of-16 correct responses, the task would be made more difficult by keeping the participant at the same presentation speed, but moving the peripheral object to a moderate level of eccentricity. Once the participant achieved two consecutive blocks with at least 12-out-of-16 correct responses at this moderate eccentricity, the task would be made more difficult by keeping the participant at the same presentation speed, but moving the peripheral object to a distant/outer level of eccentricity. Once the participant achieved two consecutive blocks with at least 12-out-of-16 correct responses at this outer eccentricity, the task would be made more difficult by increasing the presentation speed (i.e.,

making it 40 ms faster; e.g., going from 240 ms to 200 ms or going from 160 ms to 120 ms), and returning the peripheral object to the inner eccentricity. Again, the participant progressed at this speed from inner to outer eccentricity before the task was made 40 ms faster. Training at this level terminated when the participant achieved a score of 12-out-of-16 or better on at least two blocks presented at 40 ms and outer eccentricity.

3. If the participant scored below criterion (40 ms) on the Divided Attention Subtask 2, but above 80 ms on the Selective Attention Subtask 3, training began at this level. (Participants who "graduated" from the Divided Attention training above also progressed next to this training level). Participants moving here from Divided Attention training always started at 200 ms presentation time. As with Divided Attention, participants moving directly to this level of training had their initial presentation time set to their score in the baseline screening UFOV score, within 40 ms in multiples of 40 ms. The block-by-block training procedure described above (i.e., moving to the next level when there were two consecutive trials of 12-out-of-16 correct, and progressing at each speed level from inner-to-outer distracter eccentricity before moving to the next speed, which was 40 ms faster) was employed until participants achieved criterion accuracy at an 80 ms presentation speed at the outer eccentricity.

4. If the participant was below criterion (80 ms) on the Selective Attention Subtask 3, participants automatically progressed to the hardest training level, Same Different Subtask 4. (Participants who "graduated" from the Selective Attention training also progressed here, starting at a 200 ms presentation time). As with the other training tracks, the initial level of training set presentation time set to within 40 ms of baseline UFOV score on this task, in multiples of 40 ms. Again, the adaptive training method described for Tracks 2 and 3 (after two consecutive trials of 12-out-of-16 correct, participants progressed from inner-to-outer distracter eccentricity before

moving to the next speed, which was 40 ms faster) was employed until the end of training. No participants in this study reached "ceiling" on this task before concluding training.

Tetris Training

In this placebo training condition, participants were asked to play the video game Tetris, with a tutor. In the game, which is a classic 1980s arcade game, seven randomly rendered tetrominoes or tetrads - shapes composed of four blocks each - fall down the playing field (Figure 3-7). The object of the game is to manipulate these tetrominoes with the aim of creating a horizontal line of blocks without gaps. When such a line is created, it disappears, and the blocks above (if any) fall. As the game progresses, the tetrominoes fall faster, and the game ends when the stack of Tetrominoes reaches the top of the playing field. Participants' tutors provided them with game instructions, and demonstrated/model effective play. Then, the tutor acted as a "coach", as participants played the game themselves. The goal of this training was to increase participants' independence, and to increase the number of rows they could clear before ending the game. This game was selected because, **based on the work of Green and Bavelier, playing of this game for up to ten hours had little or no effect on visual attention performance in college students. Thus, this condition was construed as a "placebo control" for the Medal of Honor group. It was thought to control for contact hours with study staff, out-of-house time for older adults, and any stimulating effects of interacting with video games.** The remainder of this section describes the training procedure in greater detail.

In the first session, the tutors explained to the participants how video games are used and played. However, before the participants actually started the game, they were given some paper cuts in the same shapes as the tetraminoes that they would see on the screen (shapes composed of four blocks each). They were asked to play with them and try to fit them together (create a horizontal line without gap). Once they successfully completed the task, the tutor introduced the

game in the screen. The trainers played the game for about 10 minutes for the participants to watch, in order to model game play and the requisite skills. Next, the tutor demonstrated the controller to the participants. It was the same controller used to play Medal of Honor. However, in this game, fewer buttons were necessary. The buttons were introduced one at a time and in the beginning the participants were told not to worry about creating a horizontal line, but rather that they should attempt to get comfortable with each button. In this condition, there were no step by-step instructions on a computer screen, because there is no story line in this game. Unlike MOH, the game scenario did not change over the course of the following sessions. The participants had to repeat the same task over and over again.

As game play improved, the speed of tetramino dropping changed. In the earlier stages of game play, the pieces would drop very slowly. Once the participants mastered that level of game play, which was assessed by the game, the game would automatically move them to the next level. The task in each level was exactly the same, except that the pieces would fall faster and the participants had less time to decide where they would place each piece. Unlike the Medal of Honor game, less active visual scanning required in this game. (It should be noted, however, that participants needed to note the shape of each new tetramino at the top of the screen, while simultaneously noting the optimal position for dropping the blocks at the bottom of the screen. Thus, even in Tetris some continuous visual scanning was required, although Tetris objects were usually presented more in the central and less peripheral fixation region).

Measures

Table 3-1, presents information on each measure used in this test. A detailed description of each of these measures follows below.

Baseline Measures for Participant Characterization

MMSE - MMSE is scored by calculating the total scores of the 7 items. The minimum possible score is 0 and the maximum possible score is 30. The usual cut-off point for cognitive impairment is 23/24, with lower scores indicating cognitive impairment (Folstein, Folstein, & McHugh, 1975). Those with an MMSE score of 24 or higher were included. All participants that came for baseline assessment met this inclusion criteria. The MMSE score were required because participants might be randomized to a video game training, which involved a learning process; it was thought that persons with dementia might not permit training gains, so low MMSE scores could not profit from the interventions in this study.

Visual Acuity - A visual acuity eye test was performed using a GoodLite backlit Snellen distance-vision chart, presented at a 10-foot viewing distance. The 10-foot presentation distance was practical to accommodate in the testing office. Participants were positioned 10 feet from the chart and asked to start reading the letters on the 20/50 line and proceed downward. If the participant got more than three correct scores they would move to a more difficult level but if they got fewer than three correct they were moved to an easier level. Participants had to score higher than 20/70 to remain in the tudy. All participants that came from baseline met this inclusion criteria.

Hearing impairment – The Hearing Handicap Inventory for Adults (HHIES) (Newman, Weinstein, Jacobson & Hug, 1991) was used to evaluate hearing performance. The HHIES is composed of 10 items, with a mixed pattern of "yes" and "no" indicating less hearing handicap. Inclusion/exclusion of participants was not based on this score, but it was collected as a possible covariate and to characterize the sample. In the final tabulated score, the higher the score, the greater the severity of hearing loss.

Geriatric Depression Scale – The Geriatric Depression Scale (GDS) (Yesavage, Brink, Rose, Lum, Huang, Adey, et al., 1983) is a 30-item self-report assessment designed to identify depression in the elderly. Each item is constructed to be answered yes or no, to reduce cognitive complexity of the items. The measure was designed to minimize the influence of somatic symptoms, which may not be accurate reflections of depression in older adults. One commonly used cutoff point for mild depression is 10.

HVLT – The Hopkins Verbal Learning Test-Revised® (HVLT-R) (Shapiro, Benedict, Schretlen, & Brandt, 1999) was used to test individual memory and verbal learning performance. In this test individuals repeated a list of 12 words read by the instructor. The test consisted of three learning trials, a delayed/recall trial (20-25 minutes delay) and yes/no delayed recognition trial. This later trial consisted of a randomized list that included the 12 target words and 12 non target words, six of which are drawn from the same semantic category as the targets. Raw scores were derived for total recall, delayed recall, retention (% retained), and a Recognition discrimination index. No inclusion/exclusion was based on this score, but it was collected as a possible covariate and to characterize the sample.

Proximal Outcome Variable

A proximal outcome refers to the direct outcome being measured, and is sometimes construed as the "mechanism" by which training effects are carried to real world outcomes. In other words, in order for the training effect be transferred to the real world, the training must first be proven effective on the basic skill or ability that is trained. The proximal outcome in this study is visual attention, as assessed with the Useful Field of View test (UFOV®; Owsley, Ball, Sloane, Roenker, & Bruni, 1991; Ball, Owsley, Sloane, Roenker, & Bruni, 1993; Myers, Ball, Kalina, Roth, & Goode, 2000; Raedt., & Ponjaert-Kristoffersen, 2000; Edwards, Wadley, Myers,

Roenker, Cissell, & Ball, 2002; Ball, Berch, Helmers, Jobe, Leveck, Marsiske, et al., 2002; Roenker, Cissell, Ball, Wadley, & Edward, 2003).

Useful Field Of View (UFOV) test - The UFOV (UFOV® User's Guide®) is a computer-administered test. It measures the speed at which individuals can process information within a 30° radius visual field under a variety of cognitively demanding conditions. The test can be administered in about 15 minutes. The test is assessed binocularly and it involves the detection, localization, or identification of targets against more complex backgrounds. It consists of four subtests that assess the speed of processing under increasingly complex task demands (e.g., divided attention, selective attention). These were described in detail in the UFOV training section above. Participants end up with four subtask scores, which can also be summed into a composite. Each subtask score ranges from 16 ms (fastest) to 500 ms (slowest), and represents the average presentation time needed for the participant to perform that task with 75% accuracy. As described elsewhere in detail, the four subtasks are:

(1) Subtask 1, Speed, identify a centrally presented object as car or truck

(2) Subtask 2, Divided attention, identify a centrally presented object as car or truck, while noting the location of a peripherally presented object

(3) Subtask 3, Selective attention, identify a centrally presented object as car or truck, while noting the location of a peripheral object that is presented in clutter

(4) Subtask 4, Same-different, note whether two centrally presented objects are the same or different (two cars, two trucks, or a car and a truck), while simultaneously noting the location of a peripheral object that is presented in clutter

Primary Outcome Measures

The primary, or 'real world', outcome for this study was simulated driving performance. This primary outcome was selected because it speaks to the practical value, if any, of the visual

attention training, and extends the video game training results to a real world outcome that has not yet been adequately studied, vis-à-vis video games, in older adults. Moreover, driving performance is greatly influenced by visual attention (Ball, Owsley, Sloane, Roenker, & Bruni, 1993).

In this study, a driving simulator program was used to assess the primary outcome measure. It is difficult to measure visual attention in situ, on the road, because one cannot control the environment. A high-fidelity driving simulator was available to the researchers, which permits controlled visual environments, millisecond timing at a high sampling rate (50 Hz), and ensures the safety of participants. Of course, as a simulator, ecological validity concerns are also present. In this task, participants used a steering wheel and gas-brake-pedal controller, which was thought to enhance the realism of the simulation.

Type of simulator – The simulator used in this study was the STISM Driving simulator developed by Systems Technology Incorporated. Scenarios were presented using a Dell Optiplex GX270 CPU, 19 inch flat screen monitor, and Logitech MOMO Force Feedback steering wheel (Figure 3-8). A range of scenes was generated by the simulator. The simulator included driving controls such as accelerator, break pedal and steering wheel. Participants sat about 18' from the monitor. Participants' brake reaction distance was assessed in the driving simulator.

Simulator task warm up – First, the participants received instructions on how to operate the simulator. In this task, participants had to use the steering wheels, brakes and accelerator, as in a real car. They had about 5 minutes to practice driving the simulator before the test begun.

Simulator task: Roadway obstacle detection (dog) and responsive braking - During the test, the participants were asked to behave as they would behave in a real environment e.g.,

stopping for pedestrians, obeying the speed limit. Participants were informed that as they drove, they would encounter dogs that had been placed in different parts of the scenario (i.e, in the center of the roadway or at the side of the road, either close to or far from the road). They were instructed that the main task while driving the simulator was to visually scan the entire screen and try to detect the location of the target stimulus (i.e., dog). Each time a participant thought they saw the dog, the instant they saw it, they were instructed to perform a "brake reaction" task. Participants were instructed to "jam on the brake" (i.e., not gentle braking) when they saw a dog, even if the dog was not in or near the roadway. This represented one major difference between the simulator and real behind-the-wheel performance. In the simulator, participants needed to react as fast as possible by depressing the brake pedal when they observed the target “stimulus” that was embedded into the scenarios. Some of the “stimuli” (e.g., dogs) would be in the middle of the road, some were in the periphery. There were a total of 18 dogs through the scenarios. Participants had to depress the brake each time a dog was seen. No cars were placed behind the cars the participants were driving so there was no risk of a crash by suddenly pressing the brakes. The scenarios would gradually increase in complexity and are described further below.

Rationale for using the dog – Studies using the simulator to measure reaction time mainly use two approaches: Using a light display located on the top panel of the driver’s unit in which participants were instructed to brake as quickly as possible when the lights were illuminated (Roenker, et. al, 2003), and by displaying figure shaped images (e.g., diamond) at the monitor screen, in which participants are supposed to engage the turn signal whenever the shapes appeared on the screen (Lee et al., 2003). Although these approaches would be easier to use, it would not allow placing the “stimulus” in different parts of the scenario. Moreover, in this study we tried to replicate the UFOV subtasks in a driving simulator.

Different scenarios – The participants started driving in an "acclimation" scenario (Figure 3-9). This scenario was simply a roadway without distractions (e.g., roadside objects) and it was created to get participants familiar with the simulation projection, the steering wheels, brakes and accelerator. During this scenario, the participants were asked to depress the brakes until they were comfortable doing so. Throughout the scenarios there were speed limit signs that the participants had to obey. Participants were asked to control their speed by looking at the speedometer located in the bottom of the screen, and depressing the accelerometer as required.

Following the acclimation scenario, the participants drove through a rural scenario. In this village, there was some oncoming traffic and some houses but there was not much clutter (Figure 3-10). The entire scenario had straight roads; the participants did not have to turn right or left.

The task continued with participants driving through a small town. In this town there was more clutter and distraction as can be seen in figure 3-11.

Then the participants drove through a beach town (Figure 3-12) and then a metropolis, depicted in the subsequent figure (Figure 3-13).

Position of the dogs through the scenes- There were a total of 18 dogs located throughout the scenarios. The placement of dogs throughout the scenarios was constructed to approximate the 4 different UFOV subtasks (processing speed, divided attention, selective attention and selective attention with a same-different judgment). In this simulator task, the dogs were positioned from 0 to 110 degree eccentricities either on the right or left side of the road. Some dogs were very easy to find because they were placed either on the center of the road or at a low eccentricity and there was not much clutter next to them. Other dogs were placed in locations that were more difficult to find because there was more clutter and distractions on the road, such as a bicyclist driving in front of the participant's car.

For didactic purposes and to better understand the position of the dogs through the scenario, the different position of the dogs will be referred to by using the term “blocks”. Thus, the position of dogs was divided into four “blocks” that represented the easiest (Block 1) to hardest (Block 4) locations (e.g., in the center of the screen versus far from the road). However, block numbers do not reflect the sequence at which dog positions of varying difficulty appeared throughout the scenario, which were more or less randomly arrayed, but merely the difficulty of the different positions of the dogs through the scenario.

Block one - represented the dogs that are located in the center of the road and are the easiest to seen (between 0 and 10 degrees eccentricity). An example of a dog from Block 1 is presented in figure 3-14, this dog is positioned right in the center of the road and it is very easy to be seen. There were a total of 3 dogs in Block1.

Block two - represented the dogs located at a low to medium eccentricity but there was no clutter or distraction next to them (between 20 and 65 degrees eccentricity). An example of a dog from the second Block is presented in figure 3-15, this dog is located in the periphery, but is close to the road and there is not clutter next to it. There were a total of 6 dogs in this Block.

Block three - represented the dogs located at a higher eccentricity and with more clutter around them (between 80-110 degrees eccentricity). An example of a dog from the third Block is presented in figure 3-16, this dog is also located in the periphery, but it is not very close to the road and there is clutter around it. There were a total of 4 dogs in this Block.

Block four - represented dogs located at a low to high eccentricity but they are surrounded by clutter and distractions (between 25-90 degrees eccentricity). An example of the fourth Block of dog is presented in figure 3-17. This dog is at a medium eccentricity, however there is

substantial clutter surrounding it and distractions such as other cars driving next to it. There were a total of 5 dogs in this Block.

Although the pictures can give a good idea of the position of the dogs on the screen, it does not give a good representation of the dynamics of the simulation run, showing the clutter and distractions.

The position of each dog (with distance from the center of the road) and the sequence that they appear on the screen is shown in table 3-2.

"Filler scenarios" – The entire simulation run took about 20 minutes to complete. Between the onset of each dog there were some "filler" scenarios in which participants had to keep driving (see figures 3-18 and 3-19 for example of the "filler scenarios").

How data were collected. In this study, data were collected in two ways: 1) by simulator-generated data and, 2) behavioral data. In the case of the simulator-generated data, although the participants would drive for approximately 20 minutes, the simulator was programmed to collect data only where the dogs were located. Data started to be recorded at 400 feet before the dog could be seen and stop being collected as soon as the participant passed the dog. Between the onset of each dog, the participant drove into a "filler scenario" (as described above). As soon as the participant depressed the brake pedal, this was recorded by the simulator as a marking point. If participant did not see the dog and continued driving, there would be no marking point in that block, and the block would be recorded as an inaccurate/error trial. The simulator generated three types of data: brake reaction distance, lane maintenance, and accuracy.

(1) Brake reaction distance was measured as the distance from when the dog first appeared on the screen (whether the participant could see it or not) to the first instant when the participant first depressed the brake. The potential scores for brake reaction distance ranged from

1 to 400 meters, where 400 meters represented the case where the participant did not see the dog. The participant would score 1 if he or she pressed the brakes on the first moment the dog could be seen in the simulator and they would score 400 if they missed the dog. Because participants might drive at different speeds, there was inter-participant variability in the amount of time they would have between when the dog was first perceptible on-screen and when they would be laterally positioned with the dog. Thus, using *brake reaction time* as a dependent variable would introduce inter-individual differences in response time that had nothing do with actual reaction time, but with the driving speed. On the other hand, regardless of speed, the dog always appeared at 400 feet before the person was laterally adjacent to it; thus, brake reaction distance was selected as a dependent measure because inter-participant differences would be solely due to the amount of distance traversed before the dog was noticed (i.e., how far the participant had to drive before he/she noticed the dog). We assumed that driving distance would be more equivalent and standard between participants, and less contaminated by individual differences in driving speed.

(2) Lane maintenance score - The roadway in which the participant drove always had a width of 12 meters; the car was six meters wide, so a perfectly centered car would have a lateral lane position of 6 meters (from the left side of the road). Since the sampling rate of the simulator was 50 Hz, fifty times a second, the lateral position of the car-in-lane was assessed. Based on other recent research with the simulator (Cook, 2007), it was determined that the standard deviation of this lateral position was a good indicator of lane maintenance. The smaller the SD, the less "weaving" the participant did while driving. This indicator was assessed under the assumption that driving that was under less attentional control (e.g, because the participant was distracted by effortfully looking for the dog) would be characterized by more "weaving". If the

participant became more confident and effective in dog detection due to training, it was hypothesized that there would be less "weaving" and the standard deviation should be decreased post-training. Thus, the expectation was that lane maintenance might improve with visual attention improvements.

(3) Accuracy score - The accuracy data was related to the fact that participants depressed the brakes at that time or not. The accuracy data ranged from 0 to 18. A participant would score 0 if they could not see any dog in that trial and they would score 18 if they saw all the dogs in the trial. A composite score was calculated by computing a mean score of the 18 trials from each participant either for brake reaction distance or for accuracy. To give a better representation of how the simulator generated data was collected, figure 3-20 presents a diagram with detail description of data collection.

The behavioral data was collected by the instructor. The instructor would make notes about the participants' driving behavior throughout the run. There were situations in which bicyclists or pedestrians were close to the road and the participants would brake for the bikes or pedestrian instead of the dogs. To account for the possibility of errors (e.g., braking for pedestrians instead of dogs during the trial), the instructor collected the behavioral data. Following each run, the behavioral data was compared to the simulator-generated data for each block of dogs for each participant. For example: if in a certain block the simulator recorded an accurate trial (meaning that they depressed the brake), but according to the behavioral notes the participants stopped for a bicycle instead of the dog in that particular trial, the data was corrected in the system.

Correlation Between UFOV and Simulator Subtests

A correlation analysis was performed to explore: 1) the correlation among different group of dogs (center, low to medium eccentricity little clutter, high eccentricity much clutter, and low to high eccentricity with much clutter and distraction); 2) the correlation among the UFOV

scores (speed of processing, divided attention, selective attention and same different); and 3) the correlation among the four Blocks of dogs with the UFOV scores either at pre and posttest. Table 3-3 presents the correlations at pretest and Table 3-4 shows the correlations at posttest. At both occasions, there was positive manifold among all UFOV measures and all brake reaction distance Blocks, suggesting that in general performance was consistent across the subtasks within a measure. These correlations had a quasi-simplex pattern, meaning that adjacent subtasks/Blocks thought to be closer in difficulty/complexity were also more associated correlationally.

At pretest, Simulator Blocks 2, 3 and 4 (all had dogs at the side of the roadway, and were characterized by increasing eccentricity and clutter in the higher blocks) were all associated with UFOV subtasks 3 and 4 (Selective Attention and Selective Attention with a Same-Different judgment). Thus, the more difficult (and therefore more variable) tasks from UFOV and the Simulator were associated. The results lend some support to the idea that simulator and UFOV measures reflect, at least somewhat, overlapping constructs. However, given the fairly modest associations between them, and drawing on the logic of "indirect effects" in regression (Baron & Kenny, 1986), the correlations also imply that very large UFOV effect sizes would be needed before transfer to the simulator outcome could be expected. At posttest, there was a narrower band of transfer, with only the Block 3 simulator brake reaction distance related to UFOV tasks 2-4. This may be due partly to the fact that training may have reduced variability in the UFOV and/or simulator outcomes (due to more participants moved to ceiling-level performance), which could have attenuated correlations as well.

Secondary Outcome

This study has two secondary outcomes measures: Flow and a game design questionnaire. As discussed in the introduction, a secondary outcome measure, "Flow", explored individual's

personal experience with video game playing. This could only be administered to participants in the video game groups, and was collected during their six training sessions. This variable was included to determine one's personal experience with video game playing and how it would influence individuals' compliance with future programs using video games. This variable was operationalized by a Flow questionnaire.

The Flow experience was measured using the Flow State Scale (FSS). This scale was developed by Jackson & Marsh (1996) using the Csikszentmihalyi, (1990) concept of flow. The FSS conceptualizes Flow in nine dimensions: Challenge-skill balance, action-awareness merging, clear goals, unambiguous feedback, concentration on task at hand, sense of control, loss of self-consciousness, transformation of time and autotelic experience. These dimensions were described previously by Csikszentmihalyi (Csikszentmihalyi, 1990) and they are also related to use of games and flow. Participants in the two video game groups answered the Flow questionnaire at the end of each of the six training sessions, after they had played games with a coach for about 90 minutes. Thus, each participant had a total of six flow scores. Scores (for each trial) could range from 30-180, higher scores means more flow experience.

Game design questionnaire – The model of the game design questionnaire was adapted from a previous study designed to investigate older adults' opinion about technologies.

Sample Size

Power analysis was conducted with data from the ACTIVE clinical trial. A repeated measure design with 3 experimental groups (action video game, UFOV, and "placebo" control group) and, 2 occasions (pre-test and post-test) was used. Using the ACTIVE data, we estimated residual covariance between occasions provided by SPSS. This analysis suggested the effect size, Cohen's *f* of occasion (pre/posttest) by group interaction was 0.48, which corresponds to a medium effect size. Using NCSS/PASS program to estimate required sample size using their

effect size, it was found that groups of 16 or more participants should have adequate power to detect the critical interaction.

Table 3-1. Measures used in the study.

	Measure	Pretest	During	Posttest
Baseline measures				
	Mini Mental Status Examination (MMSE)	X		
	Snellen vision chart	X		
	Hearing Handicap Inventory for Adults (HHIES)	X		
	Geriatric Depression Scale (GDS)	X		
	Hopkin Verbal Learning Test (HVLT)	X		
Proximal outcome				
	Useful Field of View Test (UFOV)	X		X
Primary outcomes				
	Driving simulator (Brake reaction distance, lane maintenance, and obstacle detection accuracy)	X		X
Secondary outcomes				
	Flow		X	
	Game design			X

Note: MMSE = Mini Mental State Examination; HHIES = Hearing Handicap Inventory for Adults; GDS = Geriatric Depression Scale; HVLT = Hopkins Verbal Learning Test; UFOV = Useful Field of View.

Table 3-2. Sequence of the position of each dog on the scenario

Distance	Condition	Left side	Center	Right side
0	Center of road		X	
65	Low to medium eccentricity, little clutter			X
65	Low to medium eccentricity, little clutter	X		
95	High eccentricity, a lot of clutter			X
110	High eccentricity, a lot of clutter			X
80	High eccentricity, a lot of clutter	X		
10	Center of road		X	
50	Low to medium eccentricity, little clutter			X
100	High eccentricity, a lot of clutter	X		
0	Center of road		X	
20	Low to medium eccentricity, little clutter			X
40	Low to medium eccentricity, little clutter			X
40	Low to high eccentricity, a lot of clutter and distraction	X		
90	Low to high eccentricity, a lot of clutter and distraction	X		
50	Low to high eccentricity, a lot of clutter and distraction	X		
30	Low to high eccentricity, a lot of clutter and distraction			X
20	Low to medium eccentricity, little clutter	X		
25	Low to high eccentricity, a lot of clutter and distraction	X		

Table 3-3. Correlation between UFOV and simulator subtasks during pretest.

	Block_1	Block_2	Block_3	Block_4	UFOV_1	UFOV_2	UFOV_3	UFOV_4
Block_1	1							
Block_2	0.41**	1						
Blcok_3	0.27*	0.54**	1					
Block_4	0.30*	0.61**	0.56**	1				
UFOV_1	-0.10	0.26	0.24	0.21	1			
UFOV_2	-0.08	0.13	0.17	0.22	0.48**	1		
UFOV_3	0.21	0.33*	0.32*	0.42**	0.42**	0.70**	1	
UFOV_4	0.03	0.27*	0.30*	0.26*	0.15	0.32*	0.43**	1

Note: ** = p < .001; * = p < .05; UFOV_1 = processing speed subtask; UFOV_2 = divided attention subtask; UFOV_3 = selective attention subtask; UFOV_4 = selective attention with two central icons; Block_1 = block of dogs that are centered to the road; Block_2 = block of dogs on close distance to road without much clutter; Block_3 = block of dogs on far distance to road with a lot of clutter; Block_4 = block of dogs located at low to high eccentricity but they are surrounded by clutter and distractions.

Table 3-4. Correlation between UFOV and simulator subtasks during posttest.

	Block_1	Block_2	Block_3	Block_4	UFOV_1	UFOV_2	UFOV_3	UFOV_4
Block_1	1							
Block_2	0.39**	1						
Block_3	0.22	0.41**	1					
Block_4	0.42**	0.48**	0.28*	1				
UFOV_1	0.13	0.25	0.22	0.16	1			
UFOV_2	0.05	0.24	0.31*	0.22	0.22	1		
UFOV_3	-0.01	0.18	0.34*	0.21	0.19	0.69**	1	
UFOV_4	0.24	0.17	0.38**	0.16	0.18	0.41**	0.51**	1

Note: ** = p < .001; * = p < .05; UFOV_1 = processing speed subtask; UFOV_2 = divided attention subtask; UFOV_3 = selective attention subtask; UFOV_4 = selective attention with two central icons; Block_1 = block of dogs that are centered to the road; Block_2 = block of dogs on close distance to road without much clutter; Block_3 = block of dogs on far distance to road with a lot of clutter; Block_4 = block of dogs located at low to high eccentricity but they are surrounded by clutter and distractions.

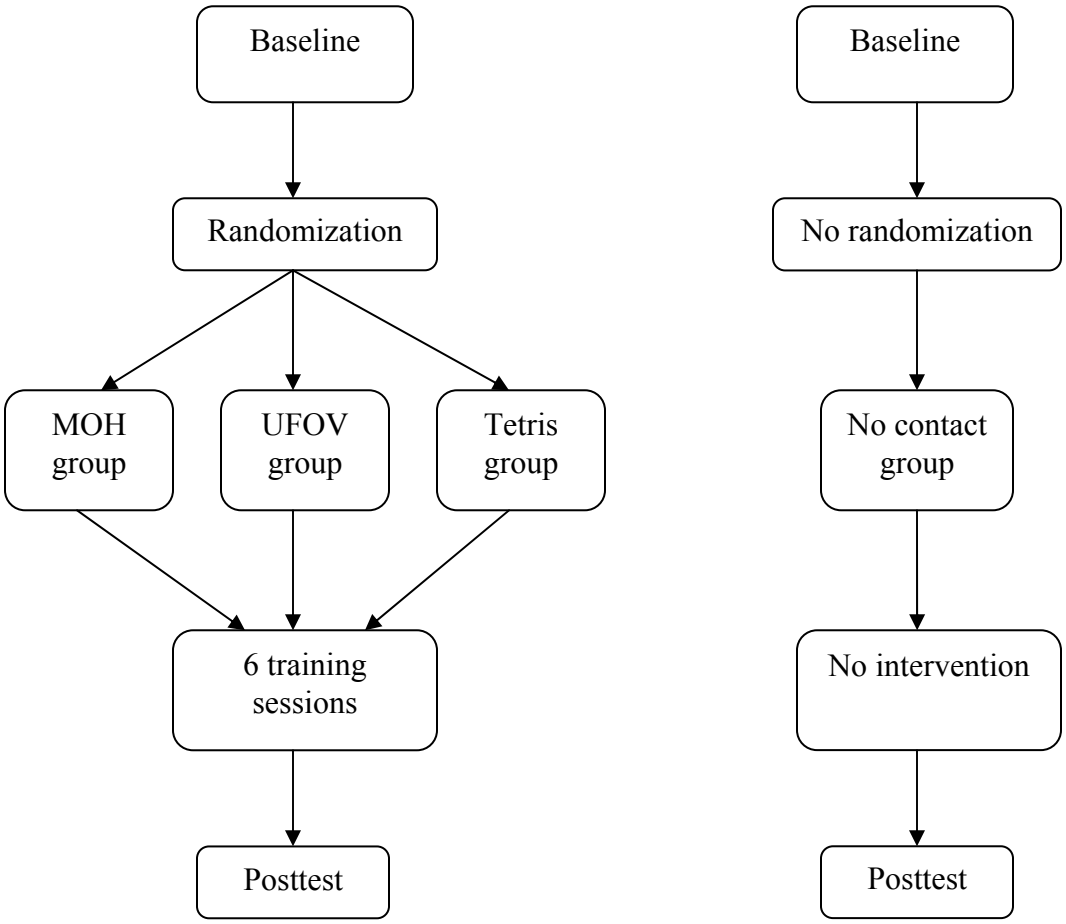
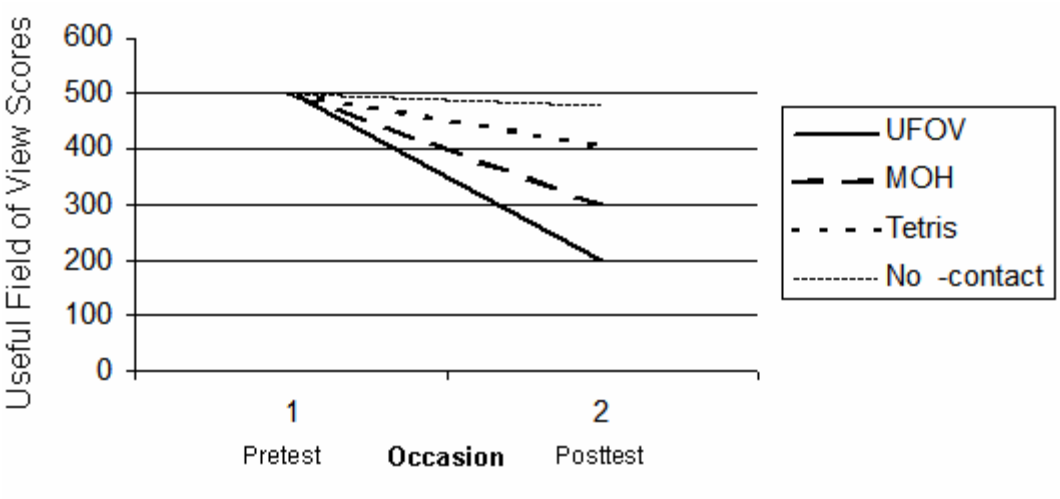
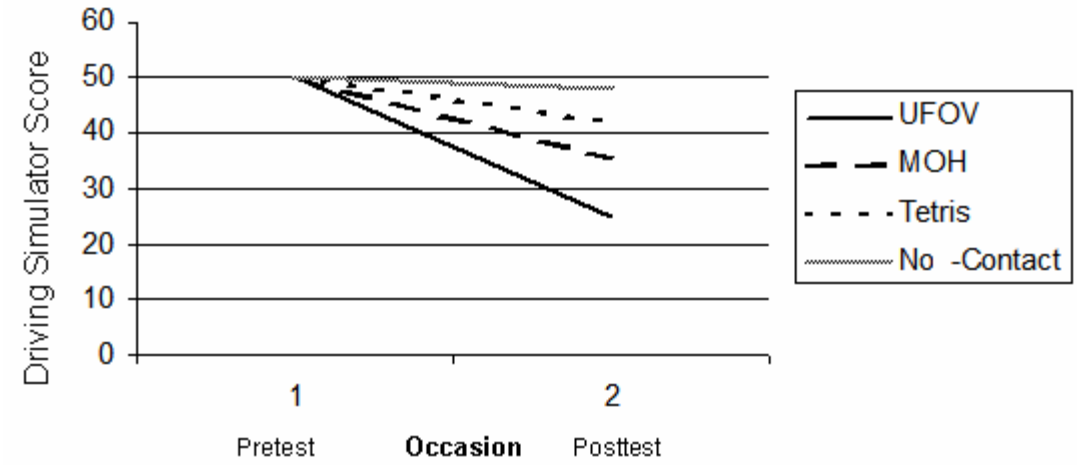


Figure 3-1. Diagram of study design presenting: Medal of Honor (MOH) group, Useful Field of View (UFOV) group, Tetris group and the no contact control group.



Note: UFOV = Useful Field of View; MOH = Medal of Honor
Figure 3-2. Hypothesis 1:



Note: UFOV = Useful Field of View; MOH = Medal of Honor
Figure 3-3. Hypothesis 2:

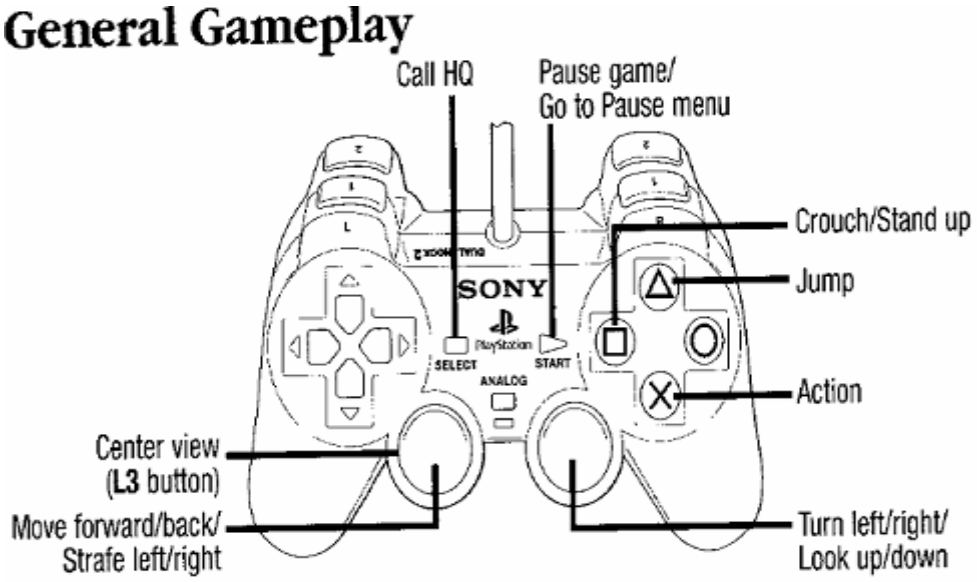


Figure 3-4. Example of the controller used by participants to play the game

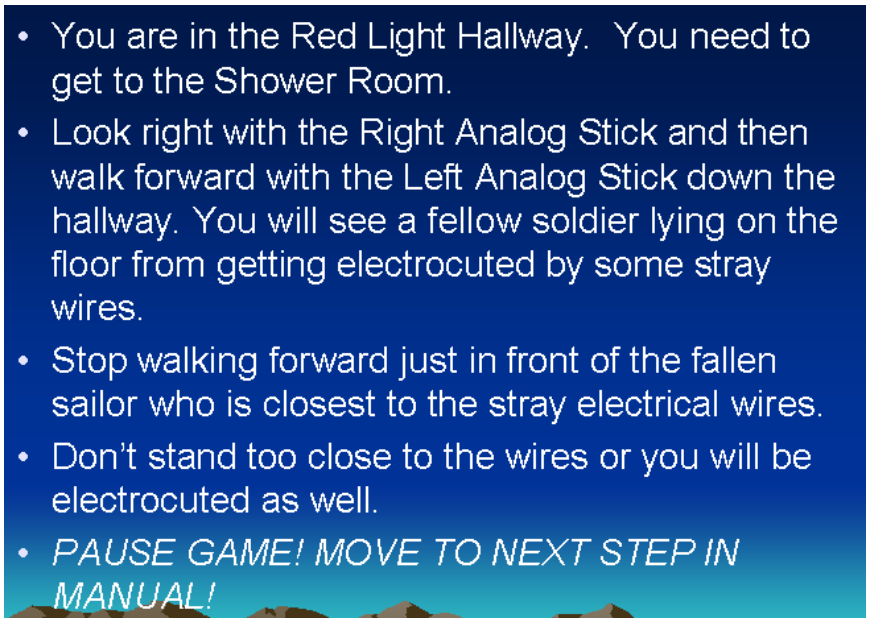


Figure 3-5. Example of a PowerPoint slide with step-by-step instructions given to participants.

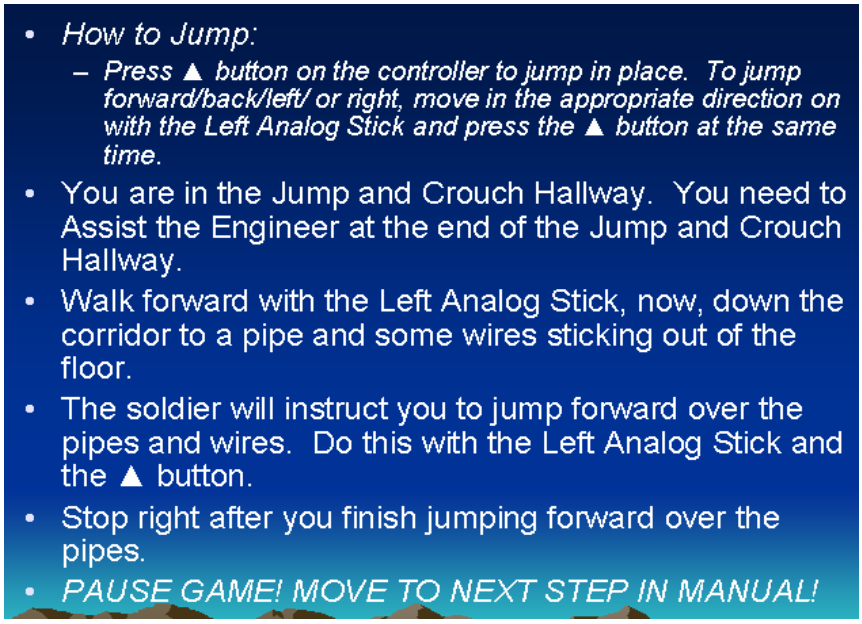


Figure 3-6. PowerPoint slide with instructions on how to use the "jump" button.

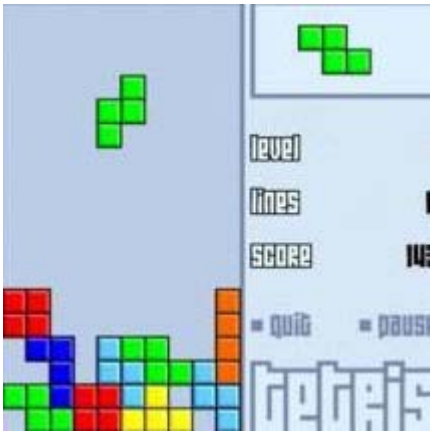


Figure 3-7. Screen shot of TETRIS game


Figure 3-8. Example of a driving simulator used in the study

Figure 3-9. Screen shot of the acclimation scenario.

Figure 3-10. Example of the rural scenario.

Figure 3-11. Example of a small town scenario

Figure 3-12. Example of a beach town scenario.

Figure 3-13. Example of a metropolis scenario

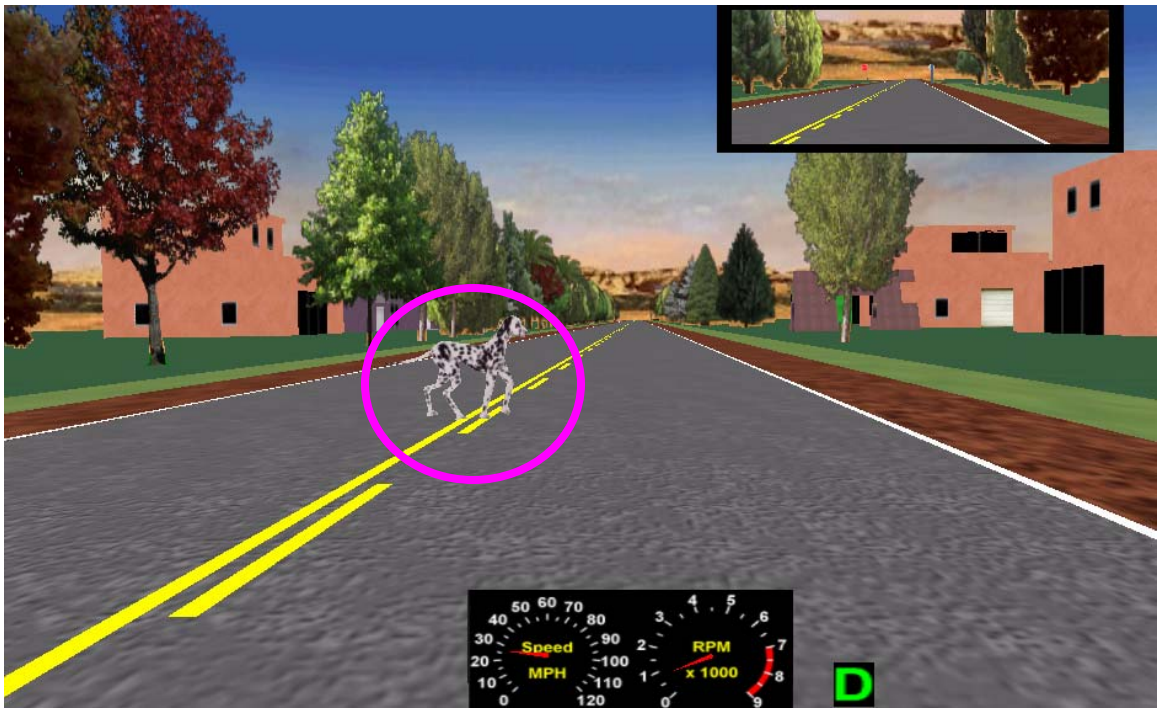


Figure 3-14. Example of a dog from block 1 – it is positioned in the center of the road.

Figure 3-15. Example of a dog from block 2 – it is positioned in a low eccentricity and without clutter.

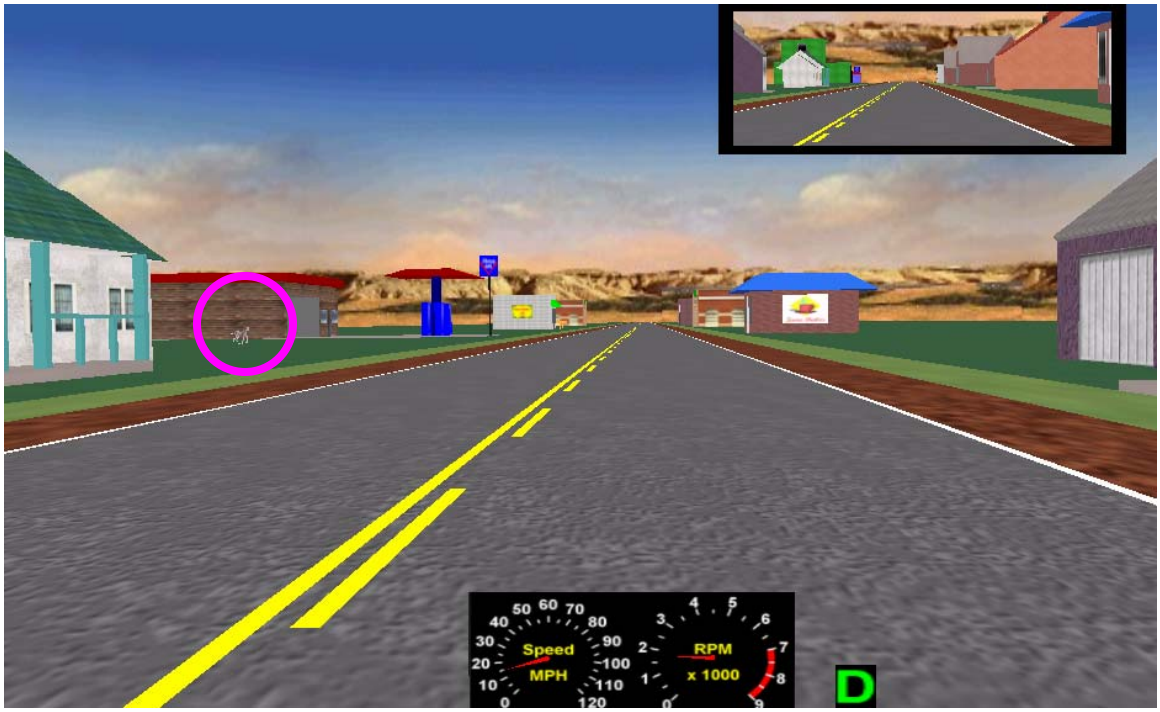


Figure 3-16. Example of a dog from block 3 – it is placed on high eccentricity with some clutter.

Figure 3-17. Example of a dog from block 4 – it is placed on a medium eccentricity but with much clutter and distraction.

Figure 3-18 – Example of a rural road scenario used as a filler scenario

Figure 3-19. Example of a city scenario used as a filler.

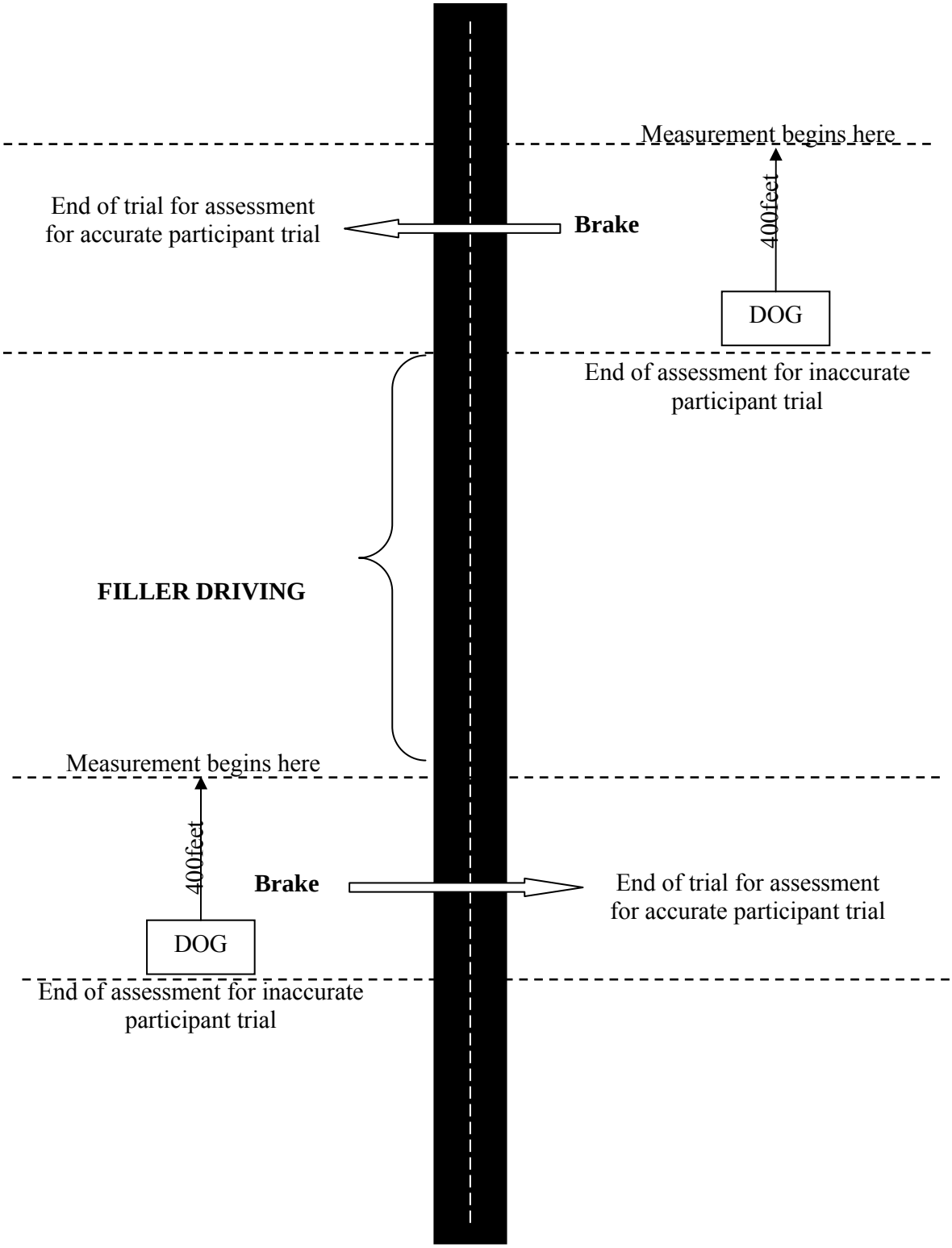


Figure 3-20. Diagram with illustration on how simulator generated data was collected.

CHAPTER 4
RESULTS

Overview

This chapter includes five broad sections. The first section corresponds to a preliminary analysis and the following sections correspond to the primary aims of this study. A preliminary analysis was conducted in order to determine whether there were differences between the training and control group at the baseline assessments, thereby addressing the effectiveness of the study's randomization. The preliminary analysis also investigated the difference between participants who completed the training and participants who dropped out of the study. This attrition analysis addressed whether dropout was selective (thereby potentially biasing the study findings). The second section examined whether older participants who received videogame training experienced gains in visual attention performance. More specifically, analyses compared four groups (Medal of Honor [MOH], Useful Field of View [UFOV], Tetris, no-contact Control) in their pretest-posttest changes in a measure of visual attention, to see whether participants in the MOH group, in particular, experienced gains comparable to traditional UFOV training, and greater than the other two groups. The third set of analyses examined whether videogame playing might also improve performance on several measures from a driving simulator (e.g., brake reaction distance, accuracy of detecting a peripheral object, and lane maintenance). The fourth set of analyses examined whether changes in perceived enjoyment and engagement ("Flow") in participants in the three intervention groups (MOH, UFOV, and Tetris), and whether the pattern of changes varied by group. The last set of analyses used descriptive statistics and anecdotal data to explore participants' opinion about videogame design.

Preliminary Analysis

Assessment of Baseline Differences Between Treatment Groups

An analysis of variance was conducted to determine whether there were differences between the four intervention groups in demographic status, age, years of education, gender, race, two cognitive measures (MMSE and HVLT), depression, and two sensory measures (visual acuity and hearing). The omnibus test revealed that there were no significant differences between the four groups, suggesting that randomization had distributed participant characteristics similarly across the groups. Table 4-1 shows the characteristics of the sample on the variables assessed, both for the total group and by intervention subgroup. *P*-values shown reflect the absence of a significant overall difference between groups.

Attrition

Given the duration and time commitment required for the current study, and the fact that twelve participants withdrew, it was important to determine whether dropout was selective. (Selectivity of dropout would suggest that the remaining sample on which the results were based was positively biased). To examine this, returning and non-returning participants were compared in baseline characteristics; specifically, analysis of variance was conducted to examine whether participants who dropped out of the study prior to its completion differed at pretest from the participants that completed the study (e.g., completed training intervention and posttest) on demographic and cognitive variables. As shown in Table 4-2, no significant differences emerged between completers and non-completers of the study protocol, suggesting that dropout did not bias the generalizability of the study findings. Also, only three participants who dropped out (one from each intervention group – MOH, UFOV, Tetris) knew to which training they were randomized because they dropped out during the training. The remaining of the participants who

dropped out (n = 9) did not know to which training they were randomized because they dropped out before the first training session, when the intervention assignment were revealed.

Aim 1: Effects of Videogame Training on Visual Attention (UFOV)

The first set of analyses examined the core four-group design that was the basis for this study. The underlying hypothesis, drawn from Green and Bavelier (2003), was that exposure to a first-person shooter action video game (MOH) would cause improvements in a measure of visual attention (the UFOV test). We sought to expand prior work in this area, which had been done with undergraduates, by considering an older adult sample. We also wanted to compare the magnitude of expected UFOV gains due to MOH by comparing the MOH intervention to the "gold standard" for this visual attention outcome, the University of Alabama-Birmingham's computer-based UFOV training program (Ball et al., 1988). Green and Bavelier had included a Tetris intervention group in their study as a placebo control, and we added that to this study as well. Finally, as described in the Methods chapter, because interim analyses suggested it might be difficult to disentangle simple pretest-to-posttest practice effects from the actual effects of videogame playing, we added a fourth non-equivalent no-contact Control group, which permitted us to compare the size of the MOH training effects, if any, to the simple effects of taking the UFOV test twice. Prior to conducting these planned analyses, we first sought to investigate whether randomization had worked to, in fact, equate groups at baseline. We assessed whether the four treatment groups were significantly different at pretest on either the UFOV composite score and or any of its' four constituent subtask scores. For none of the measures were the groups significantly different ($p > .05$).

Throughout this text η^2 is shown to indicate a partial eta-squared, which is an indicator of effect size. Values closer to 1.0 indicate a stronger effect size.

Analyses on the UFOV Composite

Our initial analysis was conducted, following published work (e.g., Ball et al., 2002; Willis et al., 2006) on the UFOV composite score. Thus, the dependent variable is the UFOV composite score (Speed + Divided attention + Selective attention score + Same-Different). The design was a mixed between-within design. The within-persons independent variable was Occasion (2: Pretest, Posttest). The between-persons independent variable was Group (4: MOH, UFOV, Tetris, no-contact Control). The critical effect of interest was the Occasion by Group interaction, which would inform us about whether there were group differences in the pattern of pre-post change. A significant main effect was revealed for Occasion (pre post), F (1, 54) = 34.07, p < .001, η^2 = .38, suggesting that, across all groups, participants tended to improve their performance. No significant main effect was found for Group, F (3, 54) = 1.4, p > .005, η^2 = .07, which suggests that there were no overall group differences, averaging across pre- and posttest. In general, this reassures that randomization equated groups. With regard to the critical Occasion by Group interaction, there was a significant interaction effect F (3, 54) = 5.8, p =.002, η^2 = .24. Thus, there was a significant differences in change by intervention group. The mean values and standard deviation for the dependent measure by group are presented in table 4-3. Pre-post change in UFOV composite performance, and group differences in change, are illustrated in Figure 4-1.

To further understand this interaction effect (i.e., which groups were changing at a different rate from others), we computed UFOV change scores (post - pre) for each participant. These were computed by subtracting the composite pretest scores from the composite posttest scores. A univariate ANOVA using change in the UFOV composite score as the dependent variable (composite posttest score – composite pretest score) was conducted. Treatment group membership was the independent variable (MOH, UFOV, Tetris, No-contact control). Results

revealed a significant main effect of group membership on UFOV change, F (3, 54) = 5.8, p = .002, η^2 = .24. Follow-up Bonferroni post-hoc t-tests were conducted to determine which groups differed from one another significantly in their UFOV change from pretest to posttest. The UFOV group improved significantly more than the Tetris group (p = .05) and the no-contact Control group (p < .01), but the difference in change between MOH and UFOV training groups did not reach significance (p = .08). Mean differences in change score, by group, are shown in Table 4-4. While the mean trends in the data suggest that participants in either videogame group improved more than the control group (see Figure 4-2), this difference did not reach significance.

We also examined this analysis on residual change scores (pretest is entered as a covariate, and posttest score is the dependent variable; because of the tendency to have high test-retest correlations between pretest and posttest, this will tend to substantially increase the statistical power of analyses on change scores), but the pattern of results was similar, and is therefore not expanded upon here in order to reduce redundancies.

Re-Examining Training Effects on UFOV by Each Subtask

The analyses on the composite score failed to find that the MOH intervention improved UFOV scores significantly more than Tetris or the no-contact Control condition. We thus decided, as a follow up analysis, to re-examine this main analysis using each of the four UFOV subtasks as distinct dependent variables. Previous research has suggested that many older adults are at ceiling on the UFOV Subtask 1 (Speed), and at floor on the UFOV Subtask 4 (Same-different), suggesting these subtasks may not be very sensitive to change. (Edwards et. a., 2006) Thus, we were particularly focused on UFOV Subtask 2 (Divided Attention) and Subtask 3 (Selective Attention). A mixed between-within ANOVA was conducted with two within-persons variables and one between-persons variable. The first within-persons variable was UFOV Task (4: Speed, Divided Attention, Selective Attention, Same-Different). The second within-persons

variable was Occasion (2: Pretest, Posttest). The between-persons variable was again Group (4: MOH, UFOV, Tetris, no-contact Control). The mean values and standard deviation for each UFOV subtest are shown by group and by occasion in Table 4-5.

A significant main effect was revealed for Occasion (pre post), F (1, 54) = 34.0, $p < .001$, $\eta^2 = .38$ and UFOV subtask F (3, 162) = 484.9, $p < .001$, $\eta^2 = .90$ but no significant main effect was found for Group F (3, 54) = 1.4, $p = .232$, $\eta^2 = .07$. For the two way interactions, a significant interaction effect was revealed for Occasion x Group, F (3, 54) = 5.8, $p = .002$, $\eta^2 = .24$ and Occasion x UFOV subtasks, F (3, 162) = 5.3, $p < .002$ $\eta^2 = .09$ but no significant interaction effects were revealed for UFOV subtask x Group F (9, 162) = 1.2, p = .248, $\eta^2 = .06$. A significant three-way interaction was found for the Occasion x UFOV subtask x Group effect, F (9, 162) = 4.5, $p < .001$, $\eta^2 = .20$.

The main effect of Occasion reflected a general decrease in the UFOV scores over time and the main effect of UFOV subtask reflected the finding that in the subtasks 3 and 4 there was more room for improvement. The Occasion x Group interaction reflected the fact that, in general, the UFOV group had greater improvement at posttest. The Occasion by UFOV subtask interaction reflected the fact that the amounts of improvement in scores at posttest was seen on particular subtasks; i.e., subtasks 3 and 4 which had more room for improvement. The significance in the three way interaction (Group x Occasion x UFOV subtask) revealed that the pattern of group differences in rates of pre-post change varied by UFOV subtask, again reflecting that group difference findings were most concentrated on UFOV subtasks 3 and 4.

To decompose the three-way interaction, a follow-up univariate two-way mixed between-within ANOVA was conducted on each of the four UFOV Subtasks (Speed, Divided Attention, Selective Attention, Same-Different). For each of these analyses, Occasion (2: Pretest, Posttest)

was the within-persons independent variable, and Group (4: MOH, UFOV, Tetris, no-contact Control) was the between-persons independent variable. The dependent measure for each of the four UFOV subtasks was the average time, in milliseconds (range = 16-500 ms) for participants to complete the subtask with 75% accuracy.

Speed of Processing Subtask

For the Speed UFOV Subtask, which assessed the speed with which participants could judge whether they had seen a car or a truck, a significant main effect of Occasion was not found F (1, 54) = .27, p = .104, η^2= .04, also there was no significant main effect of Group F (3, 54) = .75, p = .526, η^2= .04. The Occasion by Group interaction was also not significant, F (3, 54) = 1.4, p = .238, η^2 = .07. There was no improvement on this task, because participants were already at ceiling. The mean values and standard deviation for the dependent measure by group are presented in table 4-6. Figure 4-3 illustrates the change from pretest to posttest, by group, for the Speed of processing UFOV subtask.

Divided Attention Subtask

For the Divided Attention UFOV Subtask, which assessed the speed with which participants could judge whether they had seen a car or a truck while *also* looking for the peripheral location of a second car, there was a significant effect of Occasion F (1, 54) = 5.9, p = .018, η^2= .09 but there was no significant main effect of Group F (3, 54) = 1.7, p = .163, η^2= .09. The Occasion by Group interaction was also not significant, F (3, 54) = 1.0, p = .379, η^2 = .05. Thus, although there was a significant Occasion main effect (i.e., on average, all participants got better from the first to the second test), the absence of an interaction indicates that there were no group differences in change on this measure. In this test, participants were, on average, already close to ceiling. The mean values and standard deviation for the dependent measure by group are

presented in table 4-7. Figure 4-4 illustrates the change from pretest to posttest, by group, for the Divided Attention UFOV subtask.

Selective Attention Subtask

For the Selective Attention UFOV Subtask, which assessed the speed with which participants could judge whether they had seen a car or a truck while *also* looking for the peripheral location of a second car *in clutter*, the main effect of Occasion was significant F (1, 54) = 26.49, p = <. 001, η^2 = .32 but the main effect of Group was not significant F (3, 54) = .93, p = .430, η^2 = .04. The Occasion by Group interaction was significant, F (3, 54) = 4.4, p = .007, η^2 = .20. This interaction suggests that there were group differences in pre-post change on this measure. This effect is further explored with a change score analysis after the next section on the Same-Different task. The mean values and standard deviation for the dependent measure by group are presented in table 4-8. Figure 4-5 illustrates the change from pretest to posttest, by group, for the Selective Attention UFOV subtask.

Same-Different Subtask

For the Same-different UFOV Subtask, which assessed the speed with which participants could decide whether two centrally presented objects were the *same* or *different,* while also looking for the peripheral location of a second car in clutter, there was a significant main effect of Occasion F (3, 54) = 9.8, p = .003, η^2 .15 but there was no significant main effect of Group F (3, 54) = 1.9, p = .132, η^2 .09. The Occasion by Group interaction was again significant, F (3, 54) = 7.2, p < .001, η^2 = .28. Thus, the significant interaction says that there were again group differences in pre-post change on this measure, an effect which is further explored with the change score analysis that follows. The mean values and standard deviation for the dependent measure by group are presented in table 4-9. Figure 4-6 illustrates the change from pretest to posttest, by group, for the Same-Different UFOV subtask.

Change score analyses of Selective Attention and Same-Different subtasks

To further explore the significant Occasion by Group interaction for the Selective Attention subtask and the Same-Different subtask, a follow-up analysis was conducted using change scores. Specifically, for both subtasks, change scores were computed by subtracting the pretest score from the posttest scores for each subtask. Negative changes would represent improvement in performance (faster times). Additionally, Bonferroni corrected follow up t-tests were used to examine whether there were significant group differences in pre-post change scores over the two occasions. As noted above for the composite score, we also examined this analysis on residual change scores (where pretest scores on the dependent measure served as the covariate, and posttest was the dependent variable) and this did not alter the pattern of findings; details are omitted here in the service of conciseness.

Selective attention subtask using change scores - For the selective attention subtask, a significant main effect of Group was found, F (3, 54) = 4.4, p = .007, η^2 = .20. A post hoc t-test analysis using Bonferroni correction (Table 4-10) revealed that the UFOV-trained group improved significantly more ($p < .05$) than the control group. In addition, the Tetris group improved significantly more ($p < .05$) than the control group as well. The UFOV group did not improve significantly more than either the Tetris or MOH groups, and the two video game groups did not differ significantly from one another. Figure 4-7 displays the trends in the data.

Same-different change scores - For the Same Different subtask, a significant main effect of Group was also found, F (3, 54) = 7.2 $p < .001$, $\eta 2$ = .28. A post hoc analysis using Bonferroni correction revealed that the UFOV group improved significantly more ($p < .05$) than all other groups, and that this was the only significant set of comparisons in these data. Unlike the Selective Attention task, there was no evidence that either of the video game groups

improved more than the no-contact control group, and they did not differ from one another. Mean trends are shown in table 4.11, and illustrated in Figure 4-8.

Aim 2: Effects of Videogame Training on Driving Simulator Performance

Results in this section focused on our three simulator-based dependent measures: (1) Brake reaction distance, (2) lane maintenance, and (3) object detection accuracy (i.e., number of trials in which a dog was correctly detected and responded to). The intent of the analyses in this section was to examine whether videogame training might transfer to aspects of simulated driving performance. This conformed with the ultimate goal of this study, which was to investigate whether visual attention training might be transferred to a real life situation. Despite the preceding analyses, which found little support for our experimental hypotheses (i.e., that the Medal of Honor group would experience more visual attention gain than Tetris or no-contact Controls; instead, the only evidence that video games affected visual attention was for the placebo control condition, Tetris, which improved more than no-contact controls on the Selective Attention subtask of the UFOV), this planned analysis was nevertheless examined. The goal of this set of analyses was to investigate whether there were any preliminary indications of real-world transfer, even for the traditional (and highly effective) UFOV training.

Driving Simulator Subtask 1: Break Reaction Distance

Analysis on the composite Brake Reaction Distance - A mixed between-within ANOVA was conducted on Brake Reaction Distance. As a reminder, a dog appeared on screen eighteen (18) times throughout the course of the driving task. The dog always appeared on screen about 400 feet before the car was laterally adjacent to it. The 400 feet before the car was laterally adjacent to the dog is referred to as a “trial”. The position of the dog varied from center-of-road to varying degrees of eccentricity, with right-or-left positioning counterbalanced.

Participants were allowed to control their speed, in accordance with posted speed levels. Thus, Brake Reaction Time was considered not to be a useful indicator of participant response, since task difficulty and presentation rate of the dog would vary with the speed driven. Brake reaction distance was found to be less sensitive to individual differences in driving speed, and was selected as the indicator of choice. The composite score was computed as the *average* brake reaction distance, computed for all 18 trials in which the dog appeared. For "error trials" (i.e., where the dog was not detected), a "time-out" distance (set to an arbitrary maximum of 400 feet) was used.

In the mixed between-within ANOVA, the same effects as in all precedent analysis were used. Group (4, MOH, UFOV, Tetris, and no-contact Control) was the between-persons variable, and Occasion (2, Pretest, Posttest) was the within-persons variable. The dependent score was the average brake reaction distance over the 18 dog trials. There was a significant main effect of Occasion F (1, 51) = 8.5, p = .005, η^2 = .14 (indicating that people improved, requiring shorter reaction distances from pre to posttest), but the main effect of Group was not significant F (3, 51) = .04, p = .989, η^2 = .002. Analyses also revealed a non-significant Group X Occasion interaction, F (3, 51) = .85, p = .107, η^2 = .04. Although there is a significant main effect for Occasion, the absence of an interaction indicates there were no group differences on this measure. The mean values and standard deviation for the dependent measure by group are presented in table 4-12. The relationship between baseline and posttest performance are illustrated in figure 4-9.

Analysis on the Brake Reaction Distance by Trial Type - As with the Useful Field of View, a concern was that the aggregate, composite mean brake reaction distance across all 18 dog-trials may have obscured any effects that were specific to particular trial types. In particular,

since the UFOV training had the largest effects, in the preceding section, on the more difficult UFOV subtasks (Selective Attention, Same-Different), a question was whether transfer to simulator-measured Brake Reaction distance might be greatest for dog trials in which the dog was more peripherally located and/or in clutter. To further explore this question, the eighteen dog trials were grouped into four blocks of trials: (a) Block 1: Dog was located in the center of the road, (b) Block 2: Dog was located at the side of the road, but close to the road, with minimal clutter (e.g., country road), (c) Block 3: Dog was located a substantial distance from the side of the road (between 80-110 degrees eccentricity) with more clutter (e.g., the dog was located between houses or trees), and (d) Block 4: Dog was located a certain distance from the side of the road (between 25 –90 degrees eccentricity) but with extensive clutter and distraction (e.g., traffic, cyclists, pedestrians). Our question of interest was whether evidence of training transfer (from UFOV or from one of the videogame training conditions) might be greatest on the more difficult subgroups of simulator trials

A mixed between-within ANOVA was conducted, with two within-persons conditions and one between-person condition. The first within-person condition was Block (4; centered dog; dog with minimal eccentricity; dog with substantial eccentricity; dog with substantial eccentricity and clutter/distraction). The second within-person condition was Occasion (2: Pretest, Posttest). The between-person condition was Group (4: MOH, UFOV, Tetris, no-contact Control). The dependent measure was the mean brake reaction distance in each of these conditions. The mean values and standard deviation for the dependent measure by group are presented in table 4-13.

Significant effects were revealed for Occasion (pre post), F (1, 51) = 5.7, p = .020, η^2= .10; Block, F (3, 153) = 337.5, p < .001, η^2= .86; and Block X Group, F (9, 153) = 3.0, p = .005,

η^2= .15. No significant interaction was found for Occasion X Block, F (3, 51) = .74, p = .107, η^2= .04; Occasion X Group, F (3, 153) = 2.1, p = .533, η^2= .04. The three-way Occasion X Group X Block interaction was also not significant F (9, 153) = 1.3, p = .244, η^2 = 0.7.

The main effect of Occasion reflected a general reduction in brake distance over time, and the main effect of Block reflected that the conditions hypothesized to have greater difficulty (e.g., Blocks 3 and 4, where the dog was at substantial eccentricity and in clutter) had longer brake reaction distances. The Group x Block interaction seems to reflect the fact that, especially on Blocks 1 and 2, the rank order of some groups varied across the Blocks of trials.

The change between baseline and posttest performance for block 1 (Figure 4-10); block 2 (Figure 4-11); block 3(Figure 4-12) and block 4 (Figure 4-13) are also presented.

Driving Simulator Subtask 2: Lane Maintenance

A mixed between-within ANOVA was conducted on lane maintenance. The within-persons independent variable was Occasion (2: Pretest, Posttest). The between-persons independent variable was Group (4: MOH, UFOV, Tetris, No-contact Control). The critical effect of interest was the Occasion by Group interaction, which would inform us about whether there were group differences in the pattern of pre-post change. A significant main effect for Occasion was found F (1, 51) = 6.6, p = .013, η^2 = .11 but no significant main effect was found for Group F (3, 51) = .22, p = .091, η^2 = .11. With regard to the critical Occasion by Group interaction, there was no significant interaction F (3, 51) = .79, p = .503, η^2 = .04. Thus, the groups got better at lane maintenance at posttest, but there were no group difference change on this measure. The mean values and standard deviation for the dependent measure by group are presented in table 4-14. Pre-post accuracy performance and group difference in change, are illustrated in figure 4-14.

Analysis of Lane Maintenance by Trial Type - As with the brake reaction distance a concern was whether the lane maintenance might differ for particular trial types (i.e., if training improved dog detection, and this meant that drivers could attend better to lane maintenance at posttest, would this effect be particularly strong for some types of dog distracters than others?). To further explore this question, the eighteen dog trials were grouped into four blocks of trials: (a) Block 1: Dog was located in the center of the road, (b) Block 2: Dog was located at the side of the road, but close to the road, with minimal clutter (e.g., country road), (c) Block 3: Dog was located a substantial distance from the side of the road (between 80-110 degrees eccentricity) with more clutter (e.g., the dog was located between houses or trees), and (d) Block 4: Dog was located a certain distance from the side of the road (between 25 –90 degrees eccentricity) but with extensive clutter and distraction (e.g., traffic, cyclists, pedestrians). Our question of interest was whether evidence of training transfer (from UFOV or from one of the video game conditions) might be greatest on the more difficult subgroup of simulator trials.

A mixed between-within ANOVA was conducted, with two-within-persons conditions and one between-person condition. The first within-persons condition was Block (4: centered dog; dog with minimal eccentricity; dog with substantial eccentricity; dog with substantial eccentricity and clutter/distraction). The second within-person condition was Occasion (2: Pretest Posttest). The between-person condition was Group (4: MOH, UFOV, Tetris, no-contact Control). The dependent measure was the standard deviation of lane maintenance in each of the condition.

Significant effects were revealed for Occasion (pre post) F (1, 51) = 6.7, p = .012, η^2 = .11; Block F (3, 153) = 306.2, p < .001, η^2 = .85 and Block x Group F (9, 153) = 306.2, p = .031, η^2 = .14. No significant interaction was found for Occasion x Group F (3, 51) = .52, p = .667, η^2 =

.03; Occasion x Block F (3, 153) = .92, p = .363, η^2 = .01. The three way Occasion x Group x Block interaction was also not significant F (9, 153) = 1.6, p = .171, η^2 = .08. The mean values and standard deviation for the dependent measure by group are presented in table 4-15. It looks like occasion signals general improvement over time (less variability while driving), and block reflects the fact that later blocks were more difficult, so SD is great in those blocks. The block by group effect seems to reflect that the rank order of groups varies across the four different types of dog distracter trials, but doesn't seem to be a meaningful effect or one related to the interventions. The change between baseline and posttest performance is presented in the following figures: for block 1 (figure 4-15), block 2 (Figure 4-16), block 3 (Figure 4-17), and block 4 (Figure 4-18).

Driving Simulator Subtask 3: Dog Detection Accuracy

Another question regarding the driving simulator performance was whether dog detection accuracy (saw the dog or not) differed for each intervention group (i.e., if participants could accurately detect more dogs at posttest than at pretest). Did the interventions (especially UFOV and MOH) make participants more accurate detectors of roadside obstacles?

Analysis on 18-trial Dog detection accuracy - A mixed between-within ANOVA was conducted on Dog detection accuracy. The within-persons independent variable was Occasion (2: Pretest, Posttest). The between-persons independent variable was Group (4: MOH, UFOV, Tetris, No-contact Control). The critical effect of interest was the Occasion by Group interaction, which would inform us about whether there were group differences in the pattern of pre-post change. A significant main effect for Occasion was found F (1, 51) = 4.6, p = .037, η2 = .08 but no significant main effect was found for Group F (3, 51) = .22, p = .876, η2 = .013. With regard to the critical Occasion by Group interaction, there was no significant interaction F (3, 51) = .135, p = .939, η2 = .008. Thus, there was an overall increase in accuracy at the posttest but the

increase did not differ by intervention group, suggesting that it was a generalized practice effect. The mean values and standard deviation for the dependent measure by group are presented in table 4-16. Pre-post accuracy performance and group difference in change, are illustrated in figure 4-19.

We did not conduct an analysis by block type for this dependent variable, because numbers of trials in each block was very low, thus not providing enough variability in the dependent variable for the statistical analysis.

Aim 3: Changes in Engagement/Flow over the Course of Training

This set of analyses was confined to the three groups of participants who were involved in interventions (MOH, UFOV, Tetris), and constitutes the original fully randomized sample. The question to be asked here was whether there were differences in participants' *task engagement* by intervention group, and whether this changed over the course of training. One rationale for using video games to train elders' visual attention has been the assumption that games are more interesting and engaging. Thus, Flow scores were assessed from all intervention groups after each of their six intervention sessions. The resulting mixed between-within ANOVA included one within-persons factor, Occasion (6, Training Sessions 1 – 6), and one between-persons factor, Group (3, MOH, UFOV, Tetris). The dependent measure was the Flow score obtained at the end of each of the six intervention sessions. Flow scores could range from 30-180, where higher scores represented more (positive engagement) flow experience. Results revealed a significant Occasion X Group interaction, F (10, 185) = 2.0, $p < .05$, $\eta^2 = .10$. Table 4-17 shows the mean and standard deviation for each training group at each session. Figure 4-20 illustrates the six training session Flow experience trend in the data, by intervention group.

A post hoc t-test analysis using Bonferroni correction was conducted. However, given the number of comparisons (45), the resulting corrected p-value (.05/45) was so low as to not shed

any light on the reason for the significant interaction. Thus, a Least Squares Difference post-hoc analysis was conducted to provide a preliminary, exploratory insight into the interaction, acknowledging that family-wise error was probably inflated in these comparisons. Here, the six training sessions were compared to one another, separately by training group (Tables 4-18; 4-19 and 4-20). The LSD results revealed different temporal trends for the three intervention groups. For the MOH group, there was a significant increase in Flow after the first sessions (Sessions 2 and 3 were significantly greater than Session 1) and this persisted through the end (Session 5 was also significantly higher than Session 1). This suggests that participants experienced more Flow right after beginning the training sequence, and maintained these gains over time. A congruent pattern was found for the Tetris group. Although the visual pattern of Flow improvement for this group was one of monotonic linear increase over the six sessions, concretely Session 6 was significantly higher than Sessions 1 and 2. Thus, as with MOH, participants ended the training with much higher self-rated Flow experience than they began with. A very different pattern was observed for the UFOV training condition. Here, the pattern was more congruent with little change over the six sessions, with the exception of one "outlier" session, Session 4. Session 4 was significantly lower in Flow than Sessions 1 and 5. Overall, then, the results suggested that the two videogame conditions experienced growths in Flow over time, a phenomenon which was not observed in the UFOV training.

Aim 4: Qualitative Participant Interviews Regarding Game Design

A final consumer-oriented aim of this study was "qualitative" in nature, in that we wanted participants to relate their phenomenological experience with video games, and what recommendations they would make for change. These final analyses examined only the subset of participants who were in one of the two video game conditions (MOH, Tetris). A total of 27 participants, thirteen from the MOH group and fourteen from the Tetris group answered a

qualitative questionnaire. This questionnaire was given to the participants as part of their posttest battery. Descriptive analysis was used to examine this aim, and was supplemented with anecdotal data from participants.

The questionnaire was designed to measure participants' interest in videogame ownership, issues that had prevented them from using videogames in the past, and possible barriers to use of videogames in the future. A checklist was provided for each of these questions, and participants could choose multiple answers (Table 4-21). The questionnaire also asked for participants' opinions about the design of the game they played, and how they perceived video game playing might have affected them. This part of the questionnaire was open-ended, and participants' answers were grouped into post-hoc categories via the investigator's thematic analysis (Table 4-22). For the current purposes, only a single rater was used to code the themes in participants' open-ended results; thus, future congruence among multiple coders will need to be assessed.

With regard to the quantitative elements of the questionnaire, almost half of the participants (40.7%) said they were interested in owning a video game. The most cited reason for not owning a video game in the past was lack of interest (44.0%) and cost (33.3%). Correspondingly, when asked "What do you foresee preventing you from using a video game in the future?" cost was the most cited reason (40.7 %), followed by lack of interest (37.0%) and lack of knowledge of the game (14.8%).

Table 4-22 displays a summary of responses to our questions about videogame design, and about perceived benefits attributable to videogames. Not every participant answered these questions, so the number of participants who responded to each part of the questionnaire is indicated in the table. Participants reported few problems with the screen/screen size (which was a 19" CRT television), and while most of the participants reported that the controller was good, a

small sample said that the controller should be made easier to use (25.9%). When asked "How would you change these features?", most participants reported they would change nothing about the screen (55.5%) or the controller (55.0%).

With regard to perceived benefits, the most common perceived benefit reported was that of mental exercise (33.3%), but an almost equal percentage (25.0%) felt that gaming could not help them in any way.

Anecdotal data from participants who played the video games was also collected during the posttest battery. In general, it seems participants enjoyed the study/gaming experience.

"I enjoyed the training and looked forward to next class each time"

"This has been a very enjoyable experience".

"I enjoyed the whole experience whether or not it stimulated my mind (I hope it did)"

"I enjoyed the computer game. This makes a good competitive game playing with others. Thanks for introducing me to a game that I have never played before".

"The game playing was fun – at times frustrating when I did not perform well".

One pre-experimental concern (that violence, especially in the MOH game, might be off-putting to some) was affirmed by some respondents. Specifically, a subset of female participants in the action-game Medal of Honor group did express some concerns about the violence of the game

"I enjoyed learning the game, as I was curious how the games are played. I could probably become addicted to them, but I do not intend to buy one. I get no satisfaction out of killing people…"

"… I was bothered by the violent content…I found the instructors very patient and helpful. I enjoyed the experience".

The training manual and the step-by-step instructions guide developed to be used in this study seems to be generally adequate for the participants.

"Overall the training was understandable with goals that were easily identifiable and fun".

"Found the whole experience very interesting. Game was interesting and adequate…"

"The training was well conducted, challenging and the level of difficulty was adequate".

"I enjoyed the challenge of the game very much. I am continuing to play it on line at home…"

"Training was a fun experience. Testing my skills against the program. Feeling good about my success…"

Some participants commented about how the video game training stimulated their brain.

"It stimulated my brain…"

"I think the training did help stimulate my hand-eye coordination. It also helped my anticipation in looking ahead to prepare for the next action…"

In general, anecdotal data from participants suggests that video game playing can be an enjoyable experience for the participants, although the violence in the game is not appealing for some, especially female participants. The development of a manual guide with detailed instructions on game playing seems important in training older adults to play these games.

Summary

Overall, the results suggest that only UFOV training improved visual attention significantly more than the other video game training. However, although not significant, the two video game conditions experienced more visual attention gain than the no contact control group, a difference which reached significance for the Tetris group on the Selective Attention UFOV subtask. The results also suggest that the visual attention gains were not transferred to a simulator driving performance. In addition, when examining participant's engagement with the

training ("Flow"), Flow improved over time for the two video game conditions, but decreased for UFOV training group. Finally, when querying participants' opinions about the video games they had played (in the Tetris and Medal of Honor conditions only), results suggested that video games have high acceptability for this population, and are perceived as potential "mental exercise" tools by older respondents.

Table 4-1. Sample characteristics both for the total group and by intervention subgroup.

	Total Sample (N = 58)	MOH group (N = 14)	UFOV group (N = 16)	Tetris group (N = 15)	Non Contact (N = 13)	*p*-values
Age						.81
M	74.7	74.8	73.7	75.8	73.7	
(SD)	(6.4)	(6.3)	(6.2)	(8.5)	(5.3)	
Education						.72
M	16.0	15.8	15.6	16.5	16.3	
(SD)	(2.4)	(2.5)	(2.6)	(2.6)	(1.7)	
Sex						.33
Male						
N	28	9	5	7	7	
(%)	(48.3)	(64.3)	(31.2)	(46.6)	(53.8)	
Female						
N	30	5	11	8	6	
(%)	(51.7)	(35.7)	(68.8)	(53.4)	(46.2)	
MMSE						.42
M	29.8	29.2	29.2	29.4	29.0	
(SD)	(5.2)	(.97)	(1.5)	(.91)	(1.2)	
HVLT Delayed recall						.14
M	9.7	9.0	10.5	10.3	8.7	
(SD)	(2.4)	(2.7)	(1.7)	(1.3)	(3.4)	
GDS						.16
M	4.1	5.5	3.0	5.2	2.8	
(SD)	(4.1)	(4.9)	(2.6)	(5.3)	(2.4)	
Hearing						.14
M	3.7	5.7	2.0	4.3	3.1	
(SD)	(4.5)	(5.5)	(2.6)	(5.3)	(3.8)	
Vision						.26
M	85.2	87.2	86.8	86.3	79.6	
(SD)	(11.5)	(5.9)	(3.9)	(5.1)	(22.3)	
Snellen equivalent						
	20/18	20/17	20/17	20/17	20/20	

Note: MOH = Medal of Honor; UFOV = Useful Field of View; MMSE = Mini Mental State Examination; HVLT = Hopkins Verbal Learning Test-Revised; GDS = Geriatric Depression Scale.

Table 4-2. Sample characteristics for completers and non-completers of the study protocol.

	Total Sample (N = 70)	Completed (N = 58)	Drop out (N = 12)	*p*-value
Age				.69
M	74.6	74.5	75.3	
(SD)	(6.3)	(6.6)	(4.8)	
Education				.70
M	16.0	15.9	16.3	
SD	(2.3)	(2.4)	(1.9)	
Sex				.68
Male				
N	33	28	5	
(%)	(47.1)	(48.3)	(41.7)	
Female				
N	37	30	7	
(%)	(52.9)	(51.7)	(58.3)	
MMSE				.24
M	29.1	29.2	28.7	
(SD)	(1.2)	(1.2)	(1.6)	
HVLT Delayed recall				.43
M	9.6	9.7	9.0	
(SD)	(2.4)	(2.4)	(2.2)	
GDS				.21
M	4.4	4.1	6.0	
(SD)	(4.3)	(4.1)	(5.2)	
Hearing				.39
M	3.5	3.7	2.4	
(SD)	(4.6)	(4.5)	(5.1)	
Vision				.57
M	86.7	86.6	87.5	
(SD)	(5.0)	(5.1)	(4.7)	
Snellen equivalent				
	20/17	20/17	20/17	
Training group and attrition group*				.49
MOH				
N		14	5	
(%)		(31.1)	(45.5)	
Tetris				
N		15	4	
(%)		(33.3)	(36.6)	
UFOV				
N		16	2	
(%)		(35.5)	(18.2)	

Note: * = 1 participants dropped out before randomization; MOH = Medal of Honor; UFOV = Useful Field of View; MMSE = Mini Mental State Examination; HVLT = Hopkins Verbal Learning Test-Revised; GDS = Geriatric Depression Scale.

Table 4-3. UFOV composite scores before and after testing by group (mean ±SD)

	Total		MOH		UFOV		Tetris		No-contact	
	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV Composite										
M	704.48	582.59	693.00	589.43	685.31	440.06	778.80	681.13	654.69	636.92
SD	232.70	246.08	254.83	209.67	94.29	171.25	272.76	219.00	280.56	323.91

Note: MOH = Medal of Honor, UFOV = Useful Field of View

Table 4-4. Post hoc analysis of UFOV composite scores by groups.

Intervention group	Intervention group	Mean Difference	Std. Error	t	*df*	*p*. value
MOH	UFOV	141.68	55.25	2.5	28	0.08
	Tetris	-5.90	56.10	-0.1	27	1
	Control	-85.80	58.15	-1.4	25	0.88
UFOV	MOH	-141.68	55.25	-2.5	28	0.08
	Tetris	-147.58	54.26	-2.7	29	0.05
	Control	-227.48	56.37	-4.0	27	<0.01
Tetris	MOH	5.90	56.10	0.1	27	1
	UFOV	147.58	54.26	2.7	29	0.05
	Control	-79.90	57.21	-1.4	26	1
Control	MOH	85.80	58.15	1.4	25	0.88
	UFOV	227.48	56.37	4.0	27	<0.01
	Tetris	79.90	57.21	1.4	26	1

Note: MOH = Medal of Honor; UFOV = Useful Field of View

Table 4-5. Mean standardized scores and standard deviations on four UFOV subtasks by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV speed										
M	21.86	17.93	18.29	19.43	19.88	16.94	20.13	18.53	30.15	16.85
SD	19.33	3.26	3.27	4.22	5.48	2.11	8.92	3.62	39.17	2.15
UFOV divided										
M	70.74	48.83	85.36	43.43	41.69	24.56	95.73	66.67	61.92	63.92
SD	76.72	60.67	86.24	37.96	20.52	11.55	100.61	70.68	72.98	92.01
UFOV selected										
M	225.53	171.34	225.64	172.64	209.00	118.63	256.93	185.33	209.54	218.69
SD	105.82	116.52	114.76	108.39	54.44	72.71	131.91	119.85	114.22	148.38
UFOV Same different										
M	386.34	344.48	363.71	353.93	414.75	279.94	406.00	410.60	353.08	337.46
S	89.14	108.82	93.20	95.34	62.39	107.03	90.63	83.82	102.60	112.73

Note: MOH = Medal of Honor, UFOV = Useful Field of View

Table 4-6. Mean standardized scores and standard deviations for processing speed subtask by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV speed										
M	21.86	17.93	18.29	19.43	19.88	16.94	20.13	18.53	30.15	16.85
SD	19.33	3.26	3.27	4.22	5.48	2.11	8.92	3.62	39.17	2.15

Note: MOH = Medal of Honor, UFOV = Useful Field of View.

Table 4-7. Mean standardized scores and standard deviations for divided attention subtask by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV divided										
M	70.74	48.83	85.36	43.43	41.69	24.56	95.73	66.67	61.92	63.92
SD	76.72	60.67	86.24	37.96	20.52	11.55	100.61	70.68	72.98	92.01

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-8. Mean standardized scores and standard deviations for selective attention subtask by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV selected										
M	225.53	171.34	225.64	172.64	209.00	118.63	256.93	185.33	209.54	218.69
SD	105.82	116.52	114.76	108.39	54.44	72.71	131.91	119.85	114.22	148.38

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-9. Mean standardized scores and standard deviations for the same different trial subtask by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
UFOV Same different										
M	386.34	344.48	363.71	353.93	414.75	279.94	406.00	410.60	353.08	337.46
S	89.14	108.82	93.20	95.34	62.39	107.03	90.63	83.82	102.60	112.73

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-10. Post hoc analysis for selective attention subtask by group.

Intervention group	Intervention group	Mean Difference	Std. Error	t	*df*	*p*. value
MOH	UFOV	37.38	27.78	1.3	28	1
	Tetris	18.60	28.21	0.6	27	1
	Control	-62.15	29.24	-2.1	25	0.23
UFOV	MOH	-37.38	27.78	-1.3	28	1
	Tetris	-18.78	27.28	-0.6	29	1
	Control	-99.53	28.34	-3.5	27	0.01
Tetris	MOH	-18.60	28.21	-0.6	27	1
	UFOV	18.78	27.28	-0.6	29	1
	Control	-80.75	28.76	-2.8	26	0.04
Control	MOH	62.15	29.24	2.1	25	0.23
	UFOV	99.53	28.34	3.5	27	0.01
	Tetris	80.75	28.76	2.8	26	0.04

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-11. Post hoc analysis for same different trial scores by group.

Intervention group	Intervention group	Mean Difference	Std. Error	t	*df*	*p*. value
MOH	UFOV	125.03	34.52	3.6	28	<0.01
	Tetris	-14.39	35.05	-0.4	27	1
	Control	5.83	36.33	0.1	25	1
UFOV	MOH	-125.03	34.52	-3.6	28	<0.01
	Tetris	-139.41	33.90	-4.1	29	<0.01
	Control	-119.20	35.22	3.3	27	<0.01
Tetris	MOH	14.39	35.05	0.4	27	1
	UFOV	139.41	33.90	4.1	29	<0.01
	Control	20.22	35.74	0.5	26	1
Control	MOH	-5.83	36.33	-0.1	25	1
	UFOV	119.20	35.22	3.3	27	<0.01
	Tetris	-20.22	35.74	-0.5	26	1

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-12. Mean standardized scores and standard deviations for the overall driving simulator score by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
Simulator Composite										
M	243.24	230.57	244.19	226.93	248.32	227.68	237.57	231.99	242.59	236.27
SD	43.25	38.22	45.42	27.14	44.37	42.94	49.33	39.52	35.41	43.23

Table 4-13. Mean standardized scores and standard deviations on four Simulator block by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
Block1										
M	165.66	158.92	172.20	173.30	176.21	161.00	170.85	144.63	138.55	159.63
SD	50.36	53.27	49.43	54.53	40.83	52.72	57.66	53.35	49.55	55.10
Block2										
M	190.13	165.14	210.50	175.43	198.26	156.38	167.01	170.20	187.84	160.21
SD	63.21	53.72	67.09	48.13	67.40	61.96	66.70	49.65	44.41	56.47
Block3										
M	248.21	245.90	225.85	212.92	244.21	231.62	256.46	262.31	265.61	277.41
SD	68.57	71.78	59.32	66.23	72.43	72.93	76.47	70.56	63.06	66.19
Block4										
M	349.53	339.80	342.49	332.13	354.94	350.11	347.16	334.30	352.32	340.62
S	35.36	32.71	38.11	30.05	30.09	24.29	39.39	40.11	36.94	35.18

Note: MOH = Medal of Honor; UFOV = Useful Field of View

Table 4-14. Mean values and standard deviation for lane maintenance by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
Lane maintenance										
M	.679	.616	.624	.513	.738	.698	.626	.610	.720	.616
S	.188	.192	.173	.136	.164	.203	.181	.190	.227	.196

Note: MOH = Medal of Honor; UFOV = Useful Field of View

Table 4-15. Mean standardized scores and standard deviations on lane maintenance on four Simulator block by intervention groups for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
Block1										
M	0.28	0.25	0.33	0.28	0.30	0.24	0.30	0.23	0.21	0.27
SD	0.16	0.15	0.25	0.19	0.08	0.08	0.16	0.08	0.13	0.23
Block2										
M	0.31	0.26	0.37	0.28	0.32	0.25	0.27	0.27	0.31	0.24
SD	0.15	0.12	0.21	0.13	0.16	0.12	0.11	0.10	0.14	0.16
Block3										
M	0.37	0.34	0.33	0.29	0.42	0.34	0.37	0.35	0.28	0.38
SD	0.21	0.19	0.14	0.12	0.32	0.20	0.11	0.14	0.11	0.28
Block4										
M	1.60	1.48	1.35	1.11	1.72	1.80	1.46	1.46	1.86	1.46
S	0.64	0.60	0.56	0.34	0.61	0.68	0.63	0.62	0.60	0.67

Note: MOH = Medal of Honor; UFOV = Useful Field of View

Table 4-16. Mean standardized scores and standard deviation on accuracy by intervention group for pre and posttest.

	Total		MOH		UFOV		Tetris		No-contact	
Measure	pre	post	pre	post	pre	post	pre	post	pre	post
Accuracy score										
M	11.7	12.2	12.0	12.6	11.6	12.3	11.7	12.2	11.5	11.8
SD	2.4	1.8	2.5	1.6	2.5	1.5	2.5	2.2	2.3	1.8

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

Table 4-17. Mean standardized scores and standard deviations of Flow scores for the 6 training sessions, by intervention group.

	Total	MOH	UFOV	Tetris
Training Session 1				
M	115.78	106.5	123.5	116.0
SD	18.96	23.43	11.13	18.62
Training Session 2				
M	118.68	118.0	120.57	117.36
SD	20.93	23.97	17.6	22.63
Training Session 3				
M	117.35	115.58	119.36	116.86
SD	22.06	25.0	12.62	27.66
Training Session 4				
M	115.18	113.5	110.14	121.64
SD	26.23	24.51	29.92	24.19
Training Session 5				
M	120.68	118.25	119.5	123.93
SD	24.11	26.95	17.29	28.49
Training Session 6				
M	120.43	117.08	115.57	128.14
SD	27.67	28.28	23.99	30.73

Note: UFOV = MOH = Medal of Honor; UFOV = Useful Field of View

Table 4-18. Post hoc analysis for flow engagement for Medal of Honor

Occasion	Occasion	Mean Difference	Std. Error	t	*df*	*p*. value
1	2	-11.50	4.73	12	12	0.02
	3	-9.08	4.18	12	12	0.04
	4	-7.00	6.20	12	12	0.27
	5	-11.75	5.29	12	12	0.03
	6	-10.58	5.42	12	12	0.06
2	1	11.50	4.73	12	12	0.02
	3	2.42	3.94	12	12	0.54
	4	4.50	6.54	12	12	0.50
	5	-0.25	3.97	12	12	0.95
	6	0.92	5.49	12	12	0.87
3	1	9.08	4.18	12	12	0.04
	2	-2.42	3.94	12	12	0.54
	4	2.08	5.68	12	12	0.72
	5	-2.67	4.12	12	12	0.52
	6	-1.50	4.94	12	12	0.76
4	1	7.00	6.20	12	12	0.27
	2	-4.50	6.54	12	12	0.50
	3	-2.08	5.68	12	12	0.72
	5	-4.75	5.07	12	12	0.35
	6	-3.58	6.07	12	12	0.56
5	1	11.75	5.29	12	12	0.03
	2	0.25	3.97	12	12	0.95
	3	2.67	4.12	12	12	0.52
	4	4.75	5.07	12	12	0.35
	6	1.17	3.88	12	12	0.77
6	1	10.58	5.42	12	12	0.06
	2	-0.92	5.49	12	12	0.87
	3	1.50	4.94	12	12	0.76
	4	3.58	6.07	12	12	0.56
	5	-1.17	3.88	12	12	0.77

Table 4-19. Post hoc analysis for flow engagement for UFOV

Occasion	Occasion	Mean Difference	Std. Error	t	*df*	*p*. value
1	2	2.93	4.38	15	15	0.51
	3	4.14	3.87	15	15	0.29
	4	13.36	5.74	15	15	0.03
	5	4.00	4.90	15	15	0.42
	6	7.93	5.01	15	15	0.12
2	1	-2.93	4.38	15	15	0.51
	3	1.21	3.65	15	15	0.74
	4	10.43	6.05	15	15	0.09
	5	1.07	3.67	15	15	0.77
	6	5.00	5.08	15	15	0.33
3	1	-4.14	3.87	15	15	0.29
	2	-1.21	3.65	15	15	0.74
	4	9.21	5.26	15	15	0.09
	5	-0.14	3.81	15	15	0.97
	6	3.79	4.57	15	15	0.41
4	1	-13.36	5.74	15	15	0.03
	2	-10.43	6.05	15	15	0.09
	3	-9.21	5.26	15	15	0.09
	5	-9.36	4.69	15	15	0.05
	6	-5.43	5.62	15	15	0.34
5	1	-4.00	4.90	15	15	0.42
	2	-1.07	3.67	15	15	0.77
	3	0.14	3.81	15	15	0.97
	4	9.36	4.69	15	15	0.05
	6	3.93	3.59	15	15	0.28
6	1	-7.93	5.01	15	15	0.12
	2	-5.00	5.08	15	15	0.33
	3	-3.79	4.57	15	15	0.41
	4	5.43	5.62	15	15	0.34
	5	-3.93	3.59	15	15	0.28

Table 4-20. Post hoc analysis for flow engagement for Tetris

Occasion	Occasion	Mean Difference	Std. Error	t	*df*	*p*. value
1	2	-1.36	4.38	14	14	0.76
	3	-0.86	3.87	14	14	0.83
	4	-5.64	5.74	14	14	0.33
	5	-7.93	4.90	14	14	0.11
	6	-12.14	5.01	14	14	0.02
2	1	1.36	4.38	14	14	0.76
	3	0.50	3.65	14	14	0.89
	4	-4.29	6.05	14	14	0.48
	5	-6.57	3.67	14	14	0.08
	6	-10.79	5.08	14	14	0.04
3	1	0.86	3.87	14	14	0.83
	2	-0.50	3.65	14	14	0.89
	4	-4.79	5.26	14	14	0.37
	5	-7.07	3.81	14	14	0.07
	6	-11.29	4.57	14	14	0.02
4	1	5.64	5.74	14	14	0.33
	2	4.29	6.05	14	14	0.48
	3	4.79	5.26	14	14	0.37
	5	-2.29	4.69	14	14	0.63
	6	-6.50	5.62	14	14	0.25
5	1	7.93	4.90	14	14	0.11
	2	6.57	3.67	14	14	0.08
	3	7.07	3.81	14	14	0.07
	4	2.29	4.69	14	14	0.63
	6	-4.21	3.59	14	14	0.25
6	1	12.14	5.01	14	14	0.02
	2	10.79	5.08	14	14	0.04
	3	11.29	4.57	14	14	0.02
	4	6.50	5.62	14	14	0.25
	5	4.21	3.59	14	14	0.25

Table 4-21. Video game ownership and usage

Are you interested in owning a video game?	
	N (%)
Yes	11 (40.7)
No	16 (59.3)
What had prevented you in the past from owning a video game? *	
	N (%)
Lack of interest	12 (44.0)
Cost	9 (33.3)
Knowledge of the game	8 (29.6)
Lack of perceived need	6 (22.2)
Lack of time	4 (14.8)
Training not available	3 (11.1)
Too hard to learn	3 (11.1)
Others	2 (7.4)
What do you foresee preventing you from using a video game in the future? *	
	N (%)
Cost	11 (40.7)
Lack of interest	10 (37.0)
Knowledge of the game	4 (14.8)
Lack of perceived need	6 (22.2)
Lack of time	3 (11.1)
Training not available	3 (11.1)
Too hard to learn	3 (11.1)
Others	2 (7.4)

Note: * Participants could choose more than one answer.

Table 4-22. Video game features

What do you think about these features?	
	N (%)
Screen (n=26)	
Good	26 (100)
Controller	
Good	17 (62.9)
Make it easier to use	7 (25.9)
Other	3 (11.1)
How would you change these features?	
	N (%)
Screening (n = 17)	
Nothing	15 (55.5)
Others	2 (7.4)
Controller (n = 20)	
Nothing	11 (55.0)
Make it easier	7 (35.0)
Others	2 (7.4)
How do you think the video game can help you? (n=20)	
	N (%)
Mental exercise	9 (33.3)
I do not think it can help	5 (25.0)
Eye hand coordination	4 (20.0)
Others	2 (10.0)

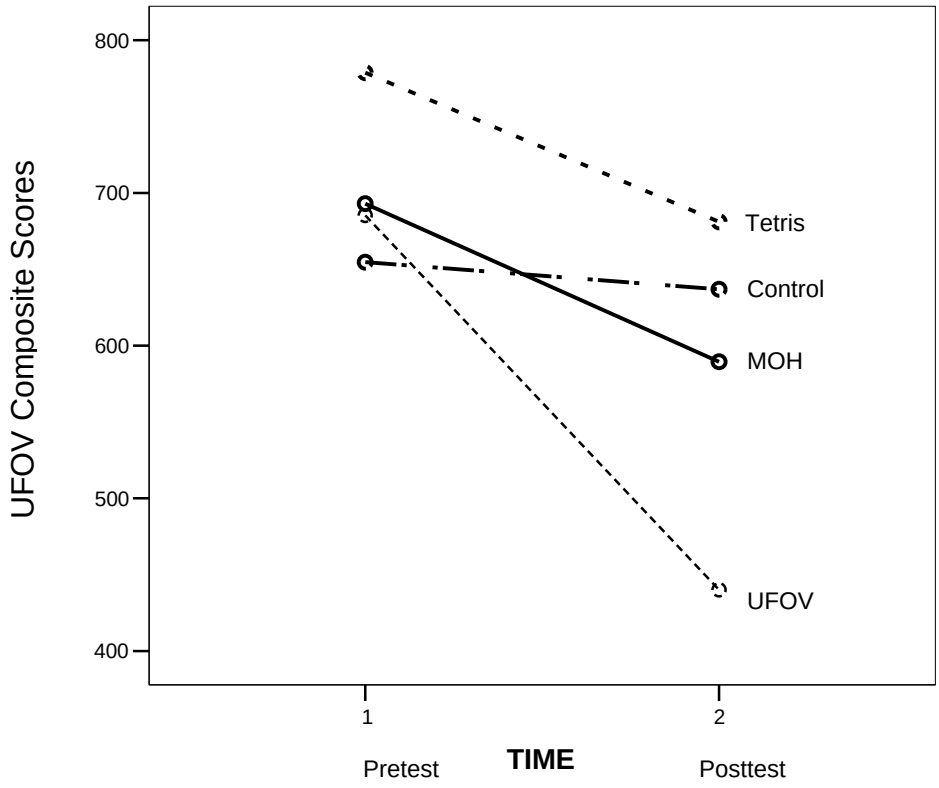


Figure 4-1. Pre-post change in UFOV composite performance, by training group
Note: MOH = Medal of Honor; UFOV = Useful Field of View.

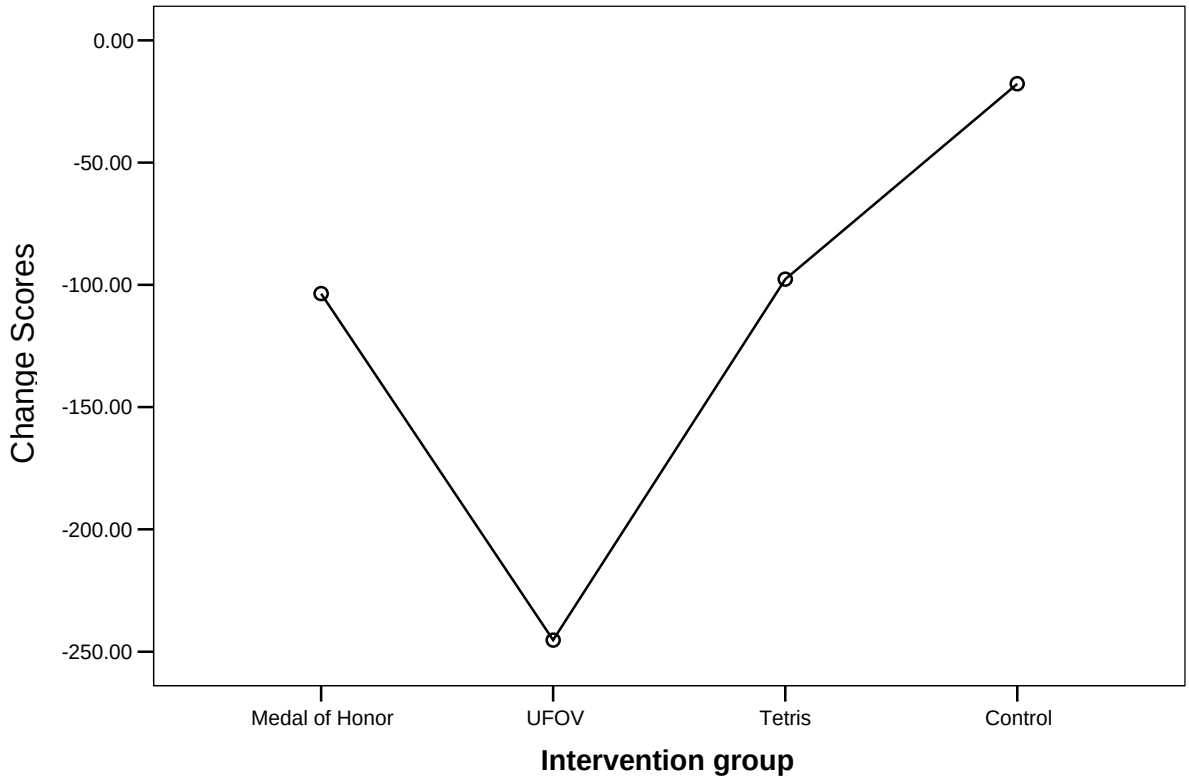


Figure 4-2. Mean UFOV composite pretest-posttest change scores, by training group
Note: UFOV = Useful Field of View

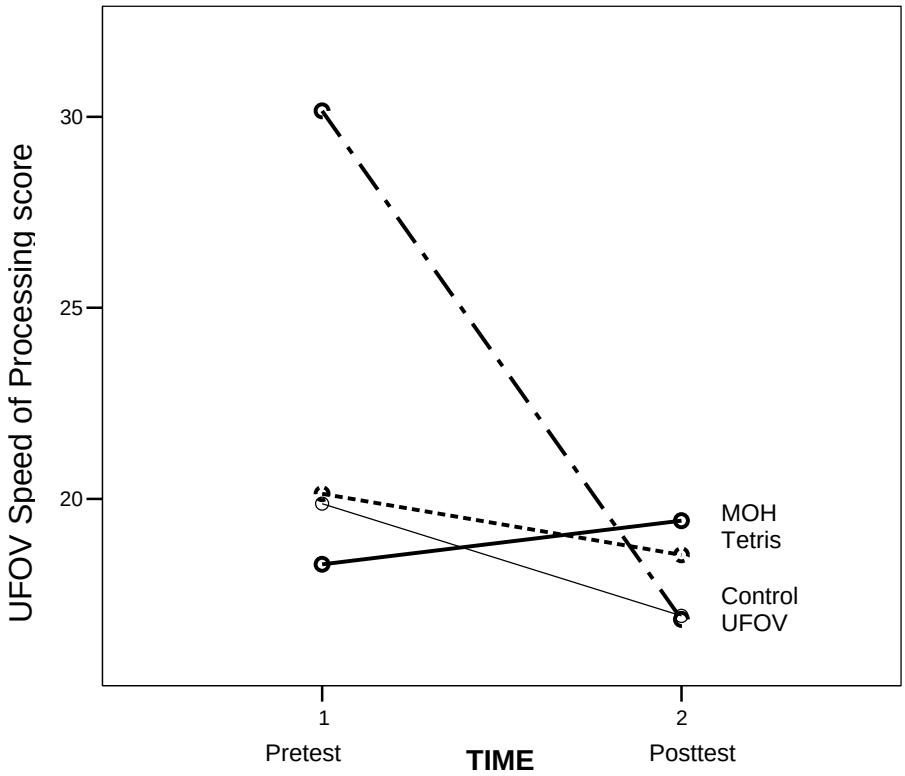


Figure 4-3. Change from pretest to posttest, by group, for the Speed of processing UFOV subtask
Note: UFOV = Useful Field of View; MOH = Medal of Honor

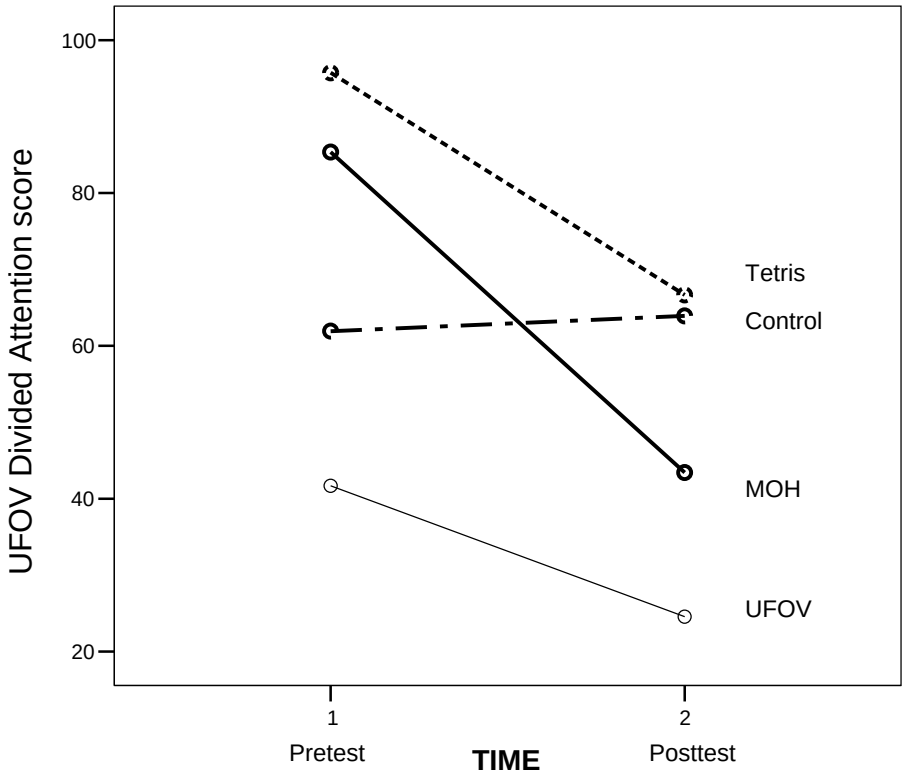


Figure 4-4. Change from pretest to posttest, by group, for the Divided Attention UFOV subtask.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

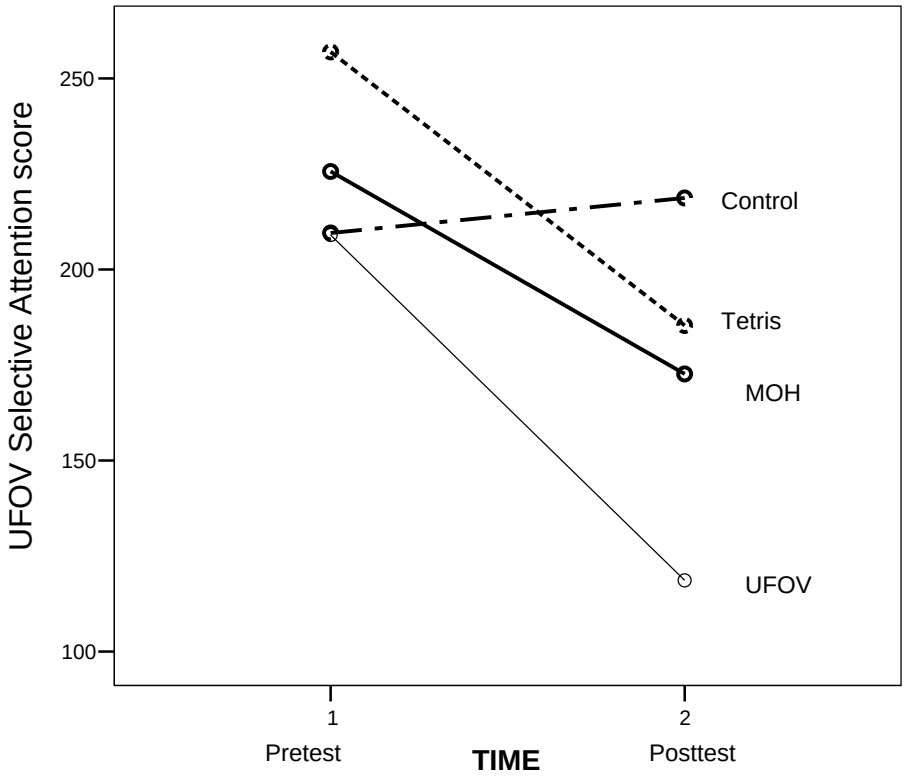


Figure 4-5. Change from pretest to posttest, by group, for the Selective Attention UFOV subtask. Note: MOH = Medal of Honor; UFOV = Useful Field of View.

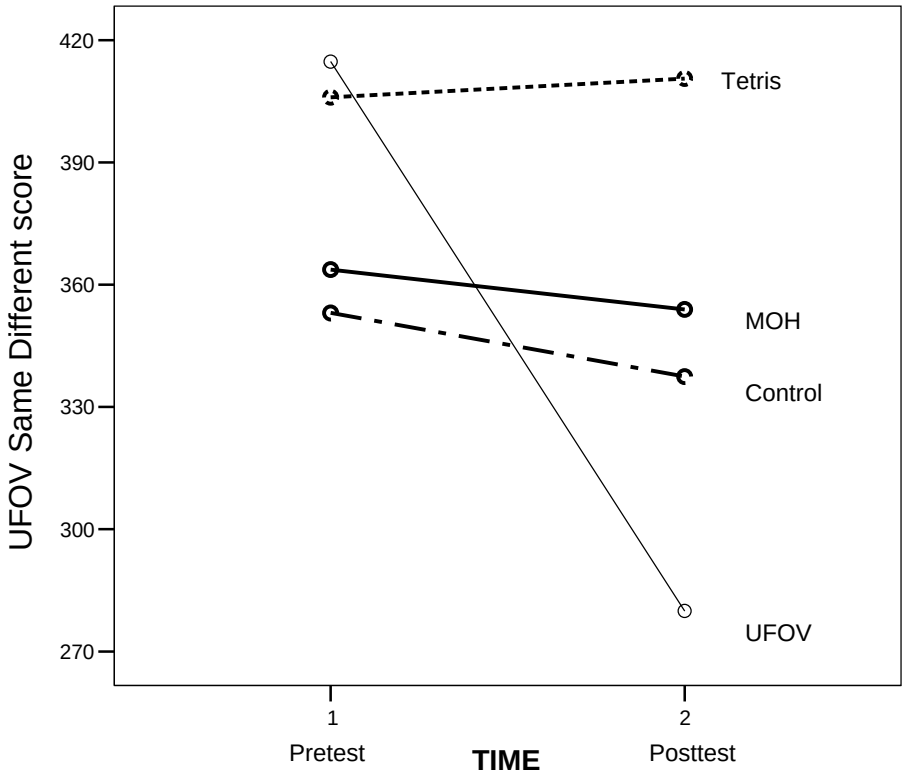


Figure 4-6. Change from pretest to posttest, by group, for the Same Different UFOV subtask.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

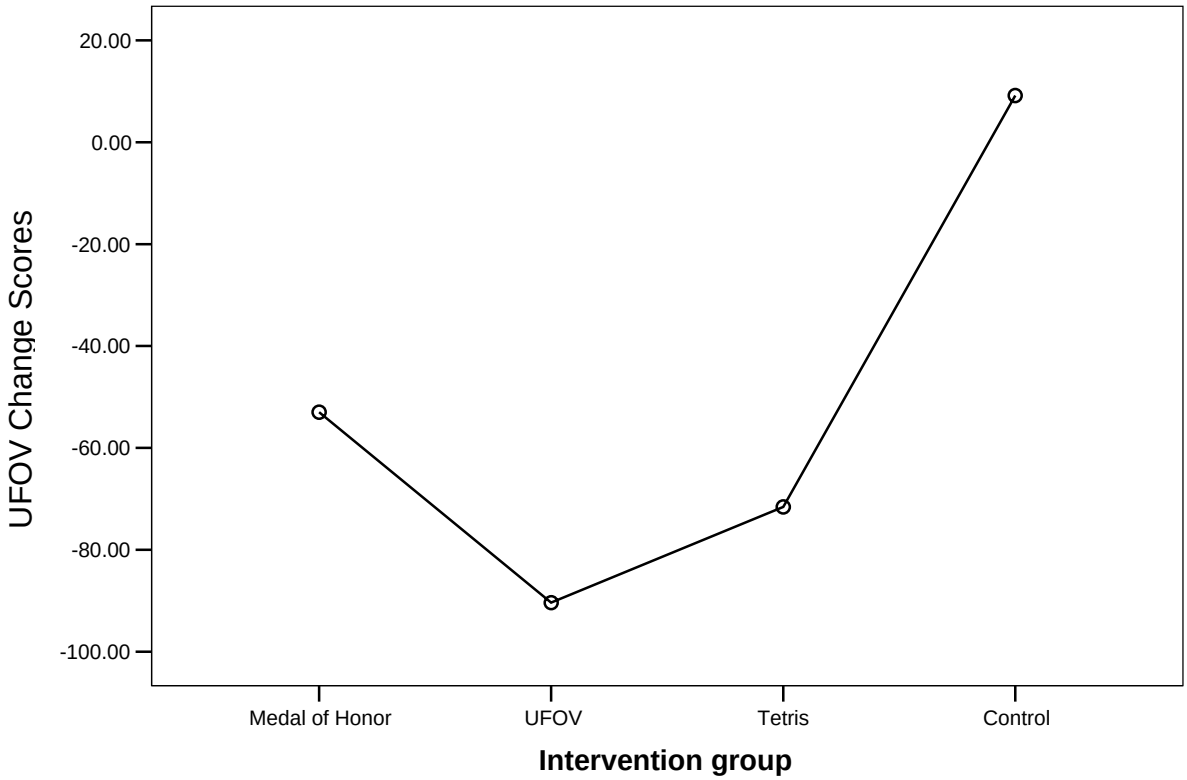


Figure 4-7. Pretest-posttest improvement on the UFOV Selective attention subtask, by treatment group

Note: UFOV = Useful Field of View

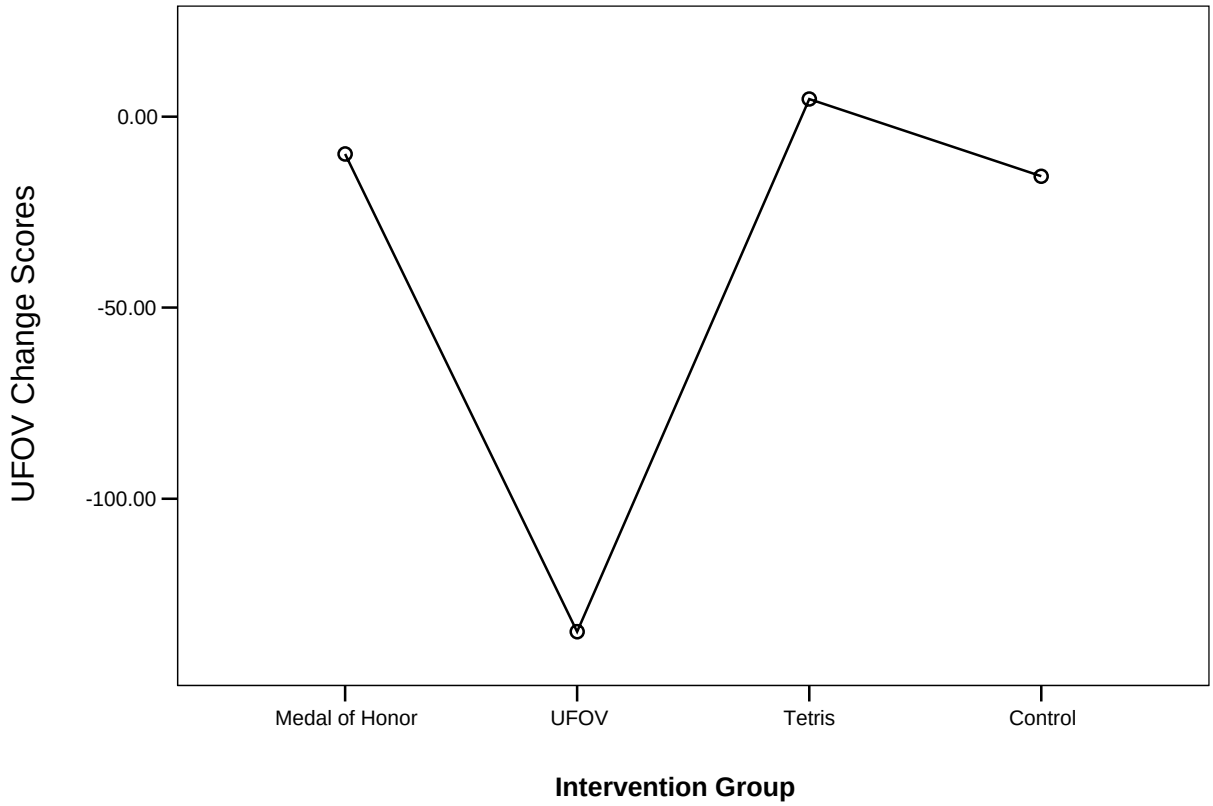


Figure 4-8. Pretest-posttest improvement on the UFOV Same-Different subtask, by treatment group

Note: UFOV = Useful Field of View

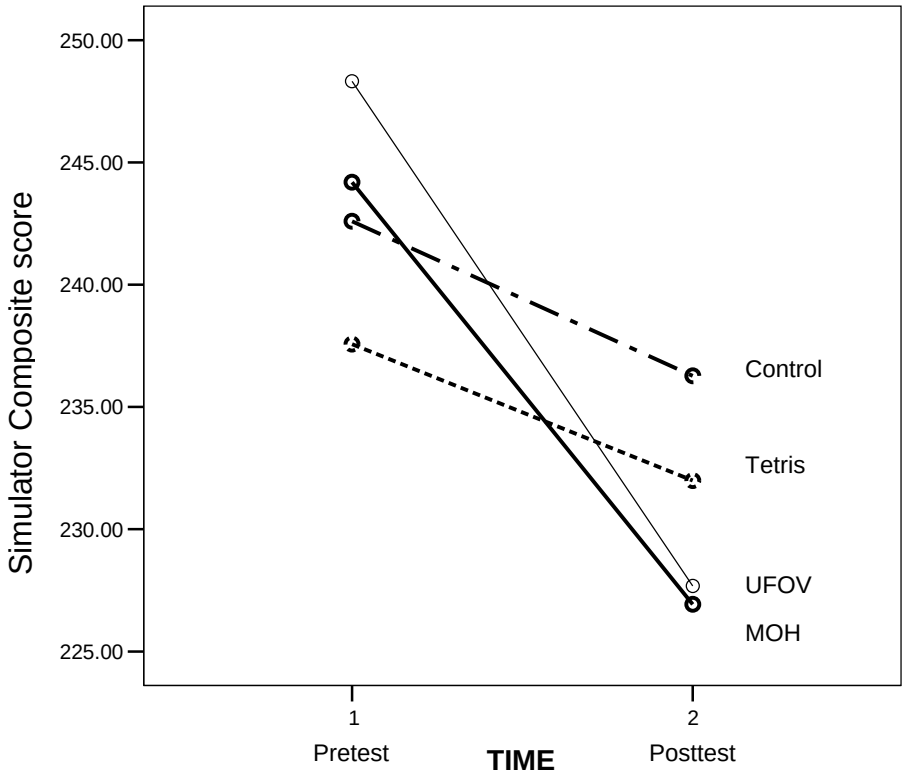


Figure 4-9. Change from pretest to posttest, by group, for the average Brake Reaction Distance (18-trial average). Distance between the onset of an on-screen dog and the depression of the brake pedal was recorded, in meters.

Note: MOH = Medal of Honor; UFOV = Useful Field of View.

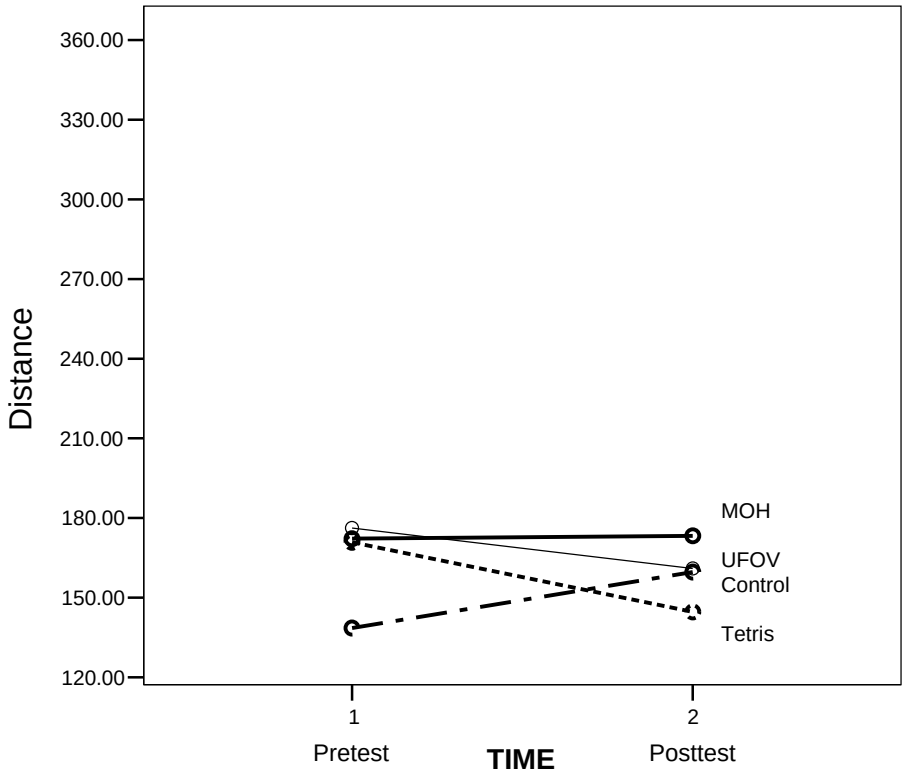


Figure 4-10. Change between baseline and posttest performance for block 1.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

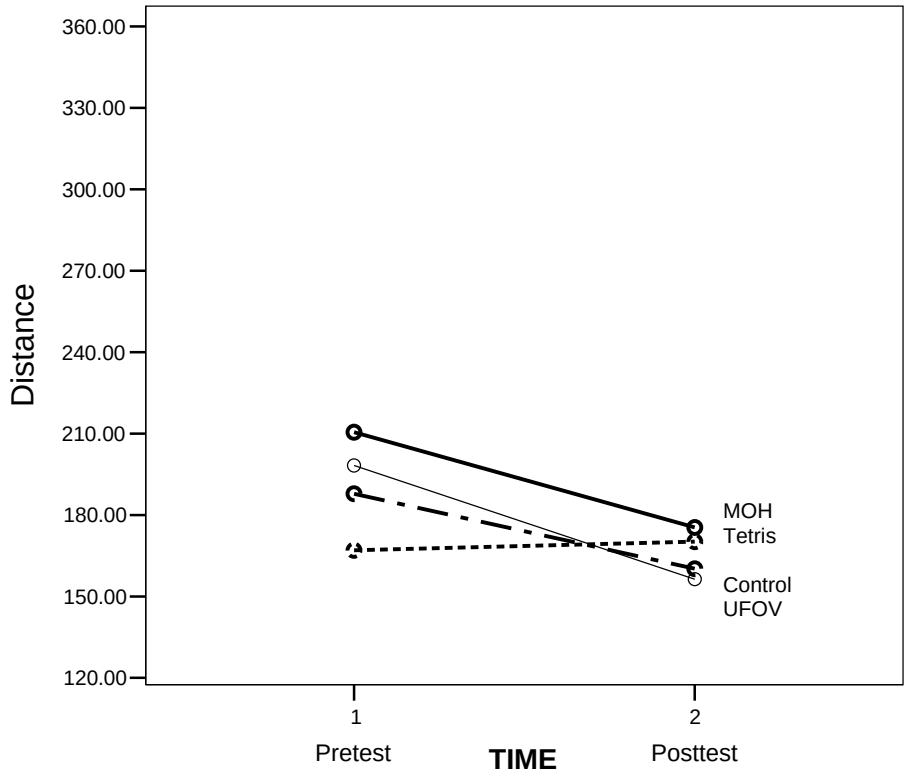


Figure 4-11. Change between baseline and posttest performance for block 2.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

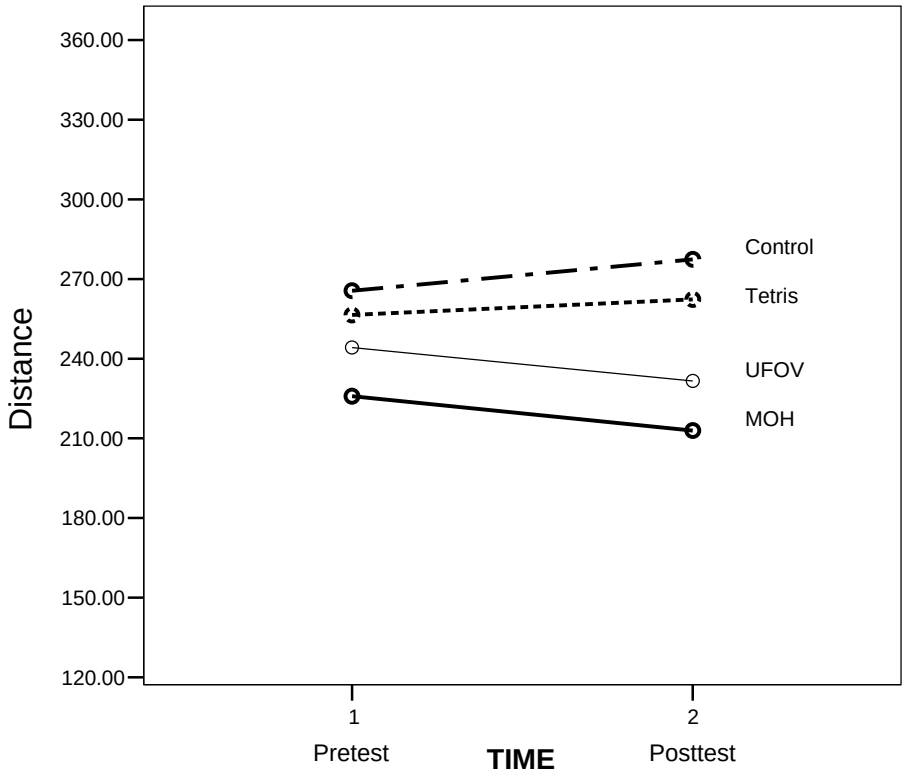


Figure 4-12. Change between baseline and posttest performance for block 3.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

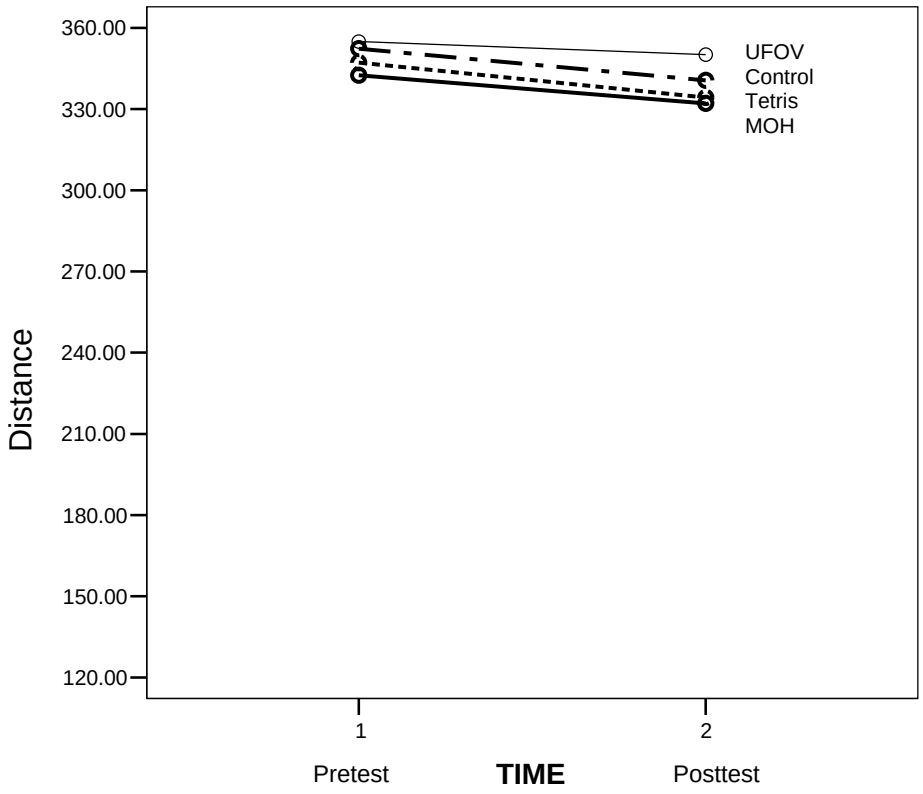


Figure 4-13. Change between baseline and posttest performance for block 4.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

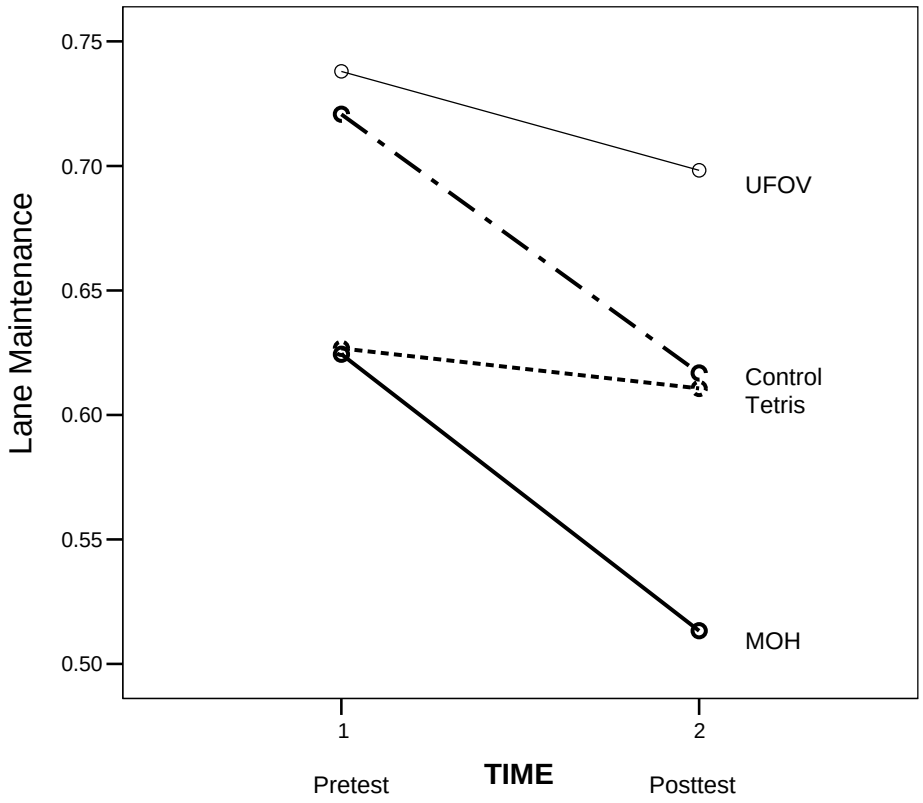


Figure 4-14. Change between baseline and posttest performance for lane maintenance.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

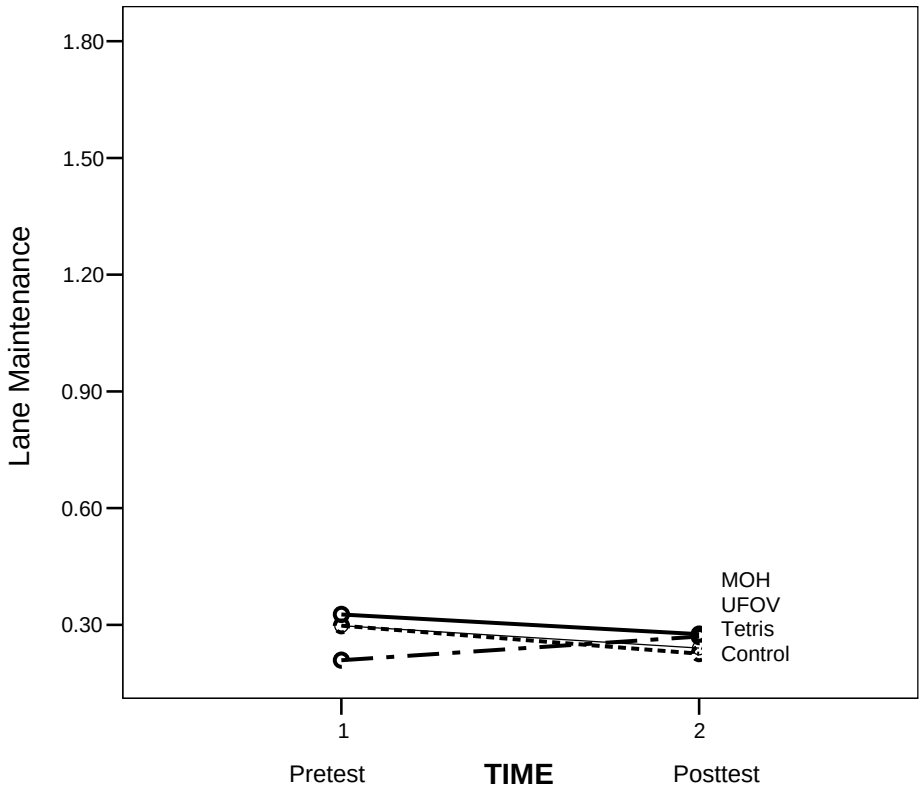


Figure 4-15. Change from pretest to posttest, by group, for the standard deviation of lane maintenance for block1.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

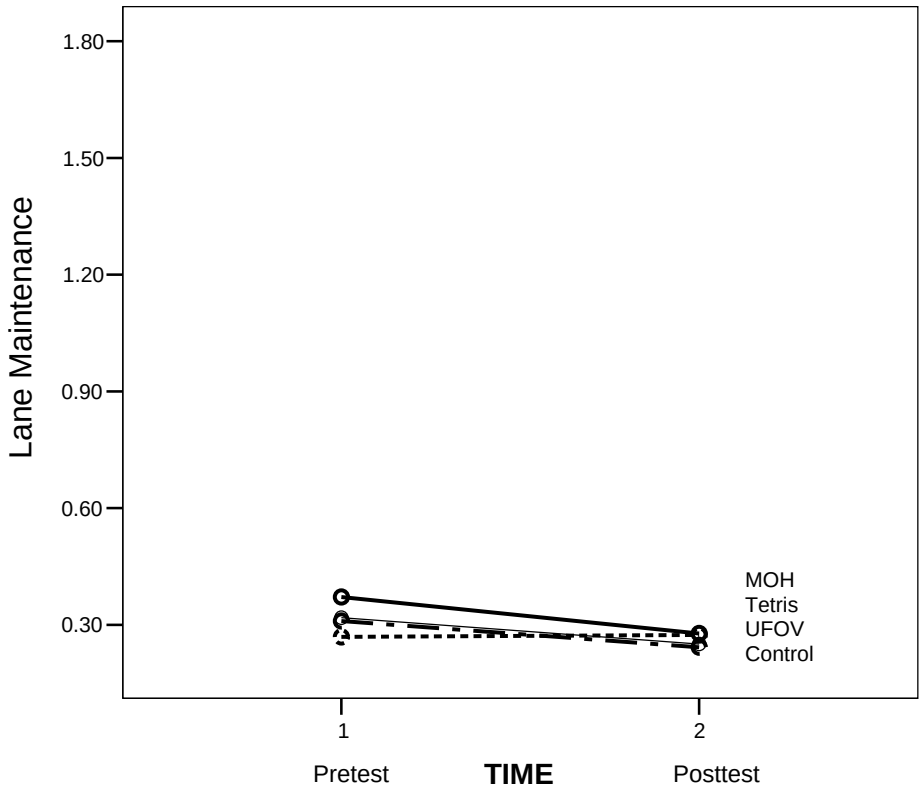


Figure 4-16. Change from pretest to posttest, by group, for the standard deviation of lane maintenance for block2.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

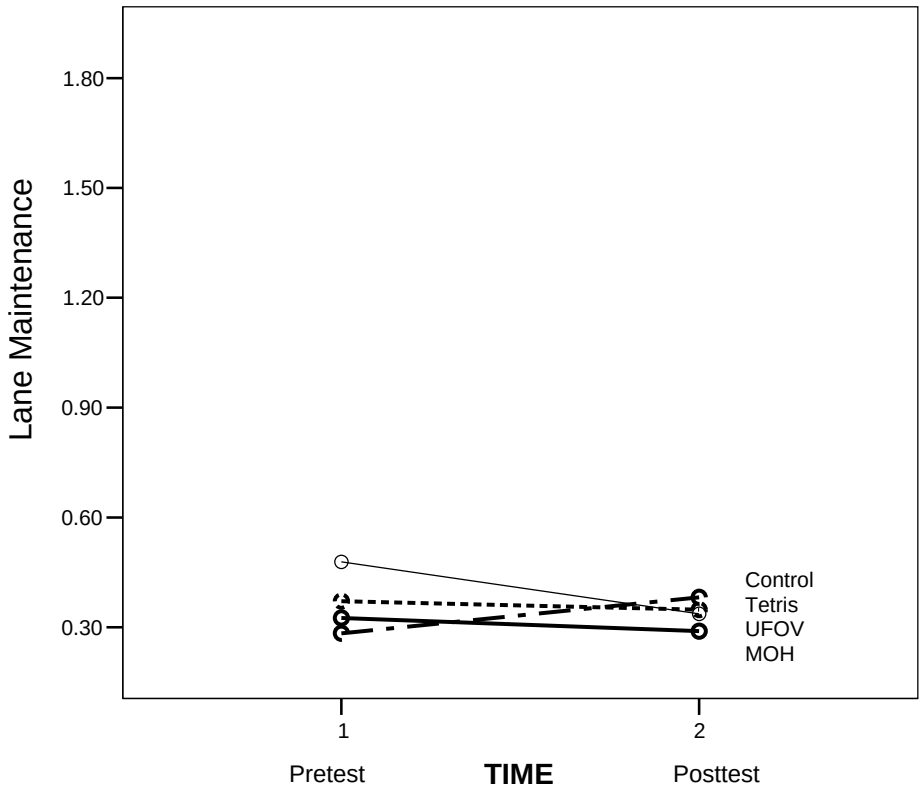


Figure 4-17. Change from pretest to posttest, by group, for the standard deviation of lane maintenance for block3.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

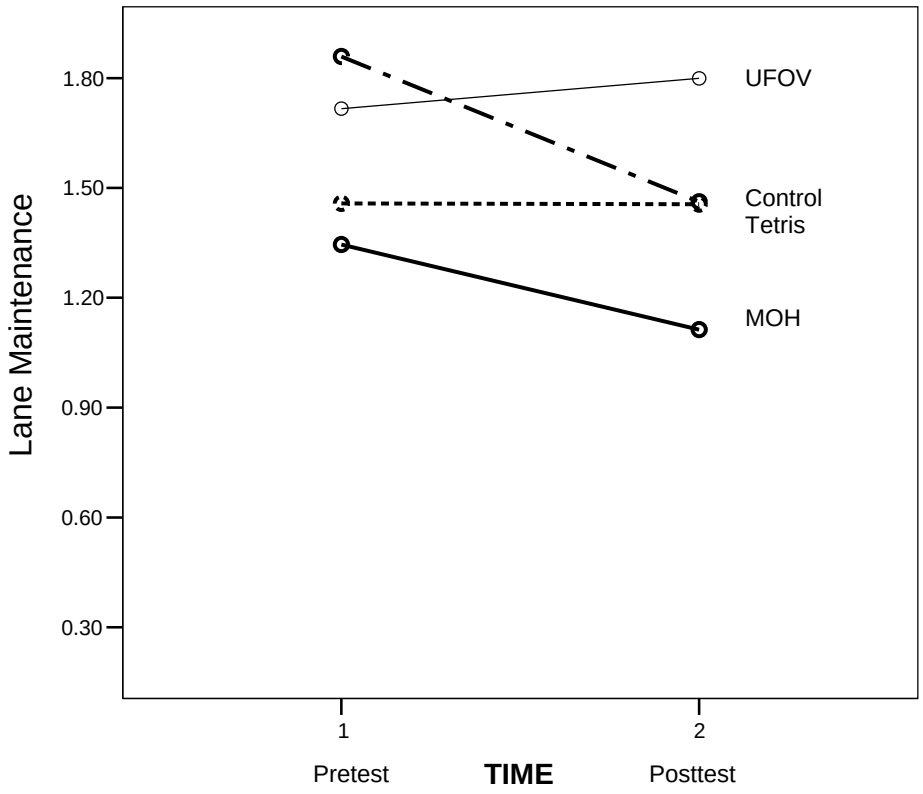


Figure 4-18. Change from pretest to posttest, by group, for the standard deviation of lane maintenance for block4.
Note: UFOV = Useful Field of View; MOH = Medal of Honor

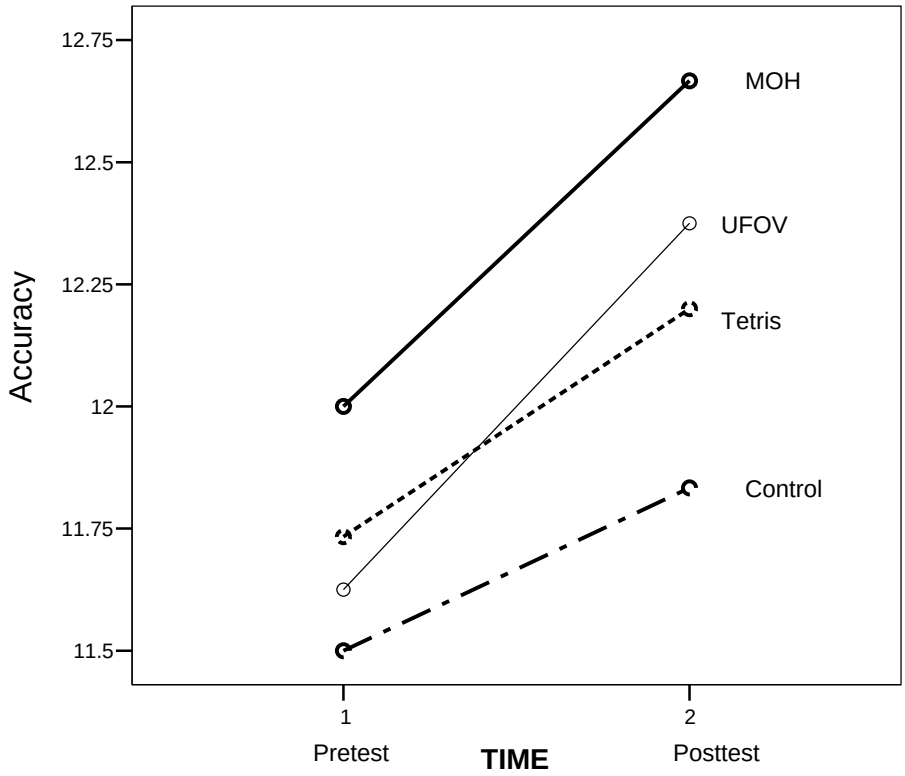


Figure 4-19. Change from pretest to posttest, by group for the accuracy (18-trial average).
Note: UFOV = Useful Field of View; MOH = Medal of Honor

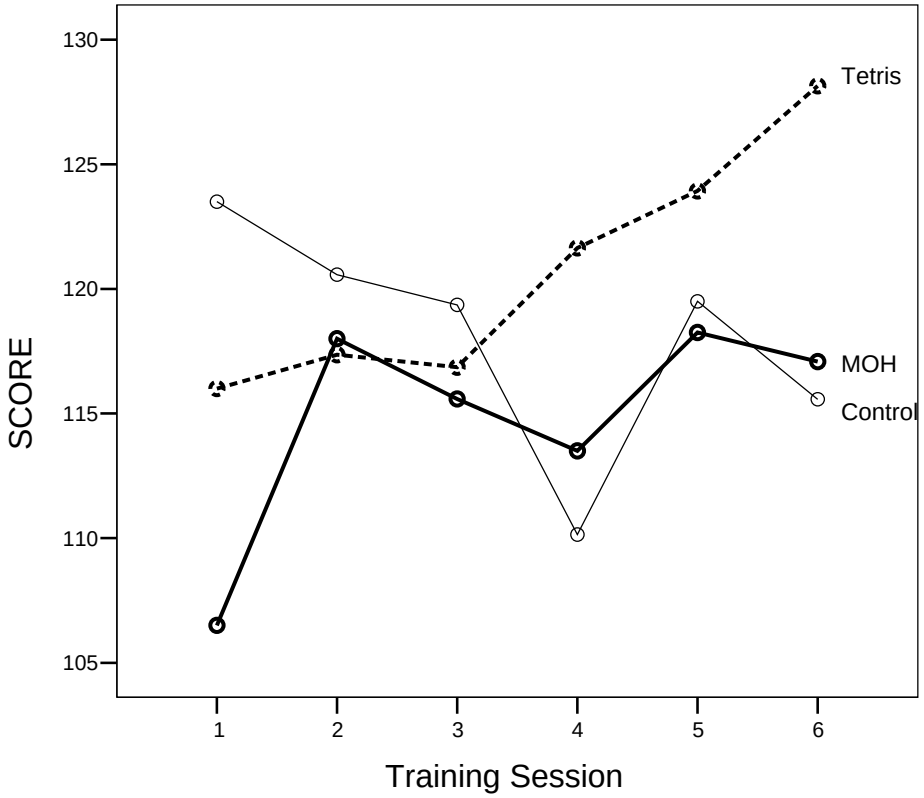


Figure 4-20. Six training session. Flow experience trend in the data, by intervention group
Note: UFOV = Useful Field of View; MOH = Medal of Honor

CHAPTER 5
DISCUSSION

Overview

This final chapter is organized into four major sections. The chapter first provides a narrative review of the major findings of this study, followed by attempts to interpret these findings. First, the major results of each study's specific aim will be reviewed. Second, a brief consideration of the limitation of the study will be considered. Finally, directions for future research on cognitive training with video games among older adults will be suggested.

Summary of Major Findings

Aim 1: Training Effects on Useful Field of View

The first aim of this study was to investigate whether UFOV performance can be improved by providing training in first person action video games (Medal of Honor (MOH)) and comparing this training to: (a) "gold- standard" touch screen based UFOV training, b) alternative video game (Tetris) construed as a placebo control and c) no-contact pre post only group. It was hypothesized that the UFOV training group would experience the most improvement in UFOV test scores; moreover, the MOH videogame group was expected to experience more gain in UFOV performance than the Tetris group and the no-contact control group (based on the work of Green and Bavelier, 2003). Results provided partial support for these hypotheses.

First, the UFOV composite score (the sum of four UFOV subtasks) was examined as a dependent variable. Overall results revealed significant improvement only for the UFOV training group, which experienced significantly more pre-post gain than the two control conditions (Tetris, no-contact).

Subsequent analysis was conducted examining the four UFOV subtasks separately as dependent measures. While there was no significant difference between groups for the easier

Speed of processing and Divided attention subtasks, there was a significant group difference in pre-post change for the Selective attention and Same-different subtasks. In the Selective attention subtask, results revealed that both the UFOV and the Tetris training groups improved significantly more than the no-contact controls. Improvement in the two videogame training conditions was not significantly different between groups, and did not differ significantly from that seen in the UFOV group. For the Same-Different subtask, the UFOV group improved significantly more than all other groups, but no other group differences (e.g., in favor of videogame training) were observed. Our next section below considers several reasons for this pattern of findings.

Aim 2: Driving Simulator Outcomes

The second aim of this study was to investigate whether video game training might transfer to simulated driving performance. Given previous research suggesting that UFOV training also yielded improved driving simulator performance (Roenker et al., 2003), it was hypothesized that the UFOV-trained participants might show more simulator improvement than all other groups. In addition, if visual attention had been boosted by MOH training, it was hypothesized that the MOH group might also show more improvement on driving simulator outcomes than the two control groups (i.e., Tetris, no-contact). The results did not support this set of hypotheses. None of the groups, including the UFOV-trained group, improved their scores disproportionately on any of the three simulator outcomes. There was, however, a general practice-related improvement on the simulator for all three groups. However, at least one simulator outcome (brake reaction distance) was significantly correlated with UFOV performance, suggesting that there was a correlational basis for expecting transfer from improved UFOV scores.

Aim 3: Changes in Flow Experience Through the Course of Training

The third aim of this study was to investigate participants' engagement with their training activities, and to assess whether there were any group differences in the pattern of change in Flow over the six training session. The analyses revealed an interesting dissociation in pattern between the two video game groups and the UFOV trained group. Although the exact pattern differed slightly between the two video game groups, in both MOH and Tetris participants ended up with significantly higher Flow ratings than they began the training with. This suggested that there was growing enjoyment of and engagement with the games over the course of training. In contrast, the overall trend in Flow for the more mechanistic UFOV training was flat. There was one outlier session (Session 4), which was significantly lower than all other sessions, but this did not seem to indicate an overall downward trend in Flow. Instead, it appeared that the two game group experienced improvements in Flow (sudden and lasting for MOH, gradually incremental for Tetris), but this was not true for the UFOV group.

Aim 4: Participants' Opinions About Game Design

The last aim of this study was to explore participants' opinion about game design. This was a consumer-oriented aim, with the goal of shaping future game design so that it might be more responsive to the needs of the older adult population.

Contrary to the stereotype that older adults are unwilling to explore new activities or take advantages of later technologies, the current study showed that this might not be the case. None of the participants from this study had previous contact with video games. This was a completely new technology for them. Recruitment of participants was not a major challenge for this study.

The results showed that almost half the participants, all video game novices, would be willing to acquire a video game system. In fact, past research gives support to the receptivity of new technologies among older adults. Previous research has supported the idea that receptivity of

new technologies is directly influenced by one's level of concern for problems that could be alleviated through the use of technology (Zimmer & Chappel, 1999). Relevant to this study, a substantial group of participants did perceive possible benefits from video games. About one third of the participants reported that they believed that the video games could serve as a positive form of mental exercise.

An encouraging finding from this study was the participants' willingness to learn how to use the video games. Anecdotally, in the early training sessions, some participants frequently expressed feelings of difficulty and challenge and even boredom with the games. But, most participants persisted with the games, and showed marked progress in game play (i.e., progressing to more difficult levels, mastering controller operation). Thus, although the pattern of transfer to UFOV test performance and driving simulator outcomes was not as strong as hypothesized, the positive comments of participants and the Flow-related findings summarized above continue to support the notion that video games may be a worthwhile and pleasing interface for cognitive interventions with older adults.

Theoretical Considerations and Study Implications

Why did we not replicate MOH training effects on visual attention?

The results of this study stand in marked counterpoint to those of Green and Bavelier (2003). Their study, with undergraduates, found that as little as ten hours of training with MOH (but not Tetris) could produce significant improvement in UFOV-like visual attention. In this study, after nine hours of MOH exposure, healthy older adults did not experience significant gain on a different version of the UFOV task. There are several possible explanations for the lack of effect.

Ceiling performance on some UFOV subtasks - Our participants did not have much room for improvement in subtask one (processing speed) and subtask two (divided attention) of

the UFOV at pre-test. Most participants performed at ceiling level (highest score possible) or close to ceiling in these two subtasks, suggesting that there may have been insufficient sensitivity to change on these tasks. Our sample performed substantially better at pretest than, for example, the ACTIVE sample (Ball et al., 2002), suggesting that the advantaged nature of our cohort may have affected training outcomes.

The third (selective attention) and fourth subtasks (same-different) offered higher levels of challenge to participants, and correspondingly, it was these two tasks that varied across training groups. However, even for these tasks, results suggested no effect of video game training (Same-different task) or a counter-intuitive effect (Tetris, not MOH, improved more than no-contact controls).

Insufficient training dosage in the video game conditions - The second explanation for the absence of expected training findings may be related to the time that participants spent learning how to play each of the video games. It was hypothesized that participants from the MOH group would show more improvement than participants who received Tetris training. The rationale for this hypothesis was taken from previous studies on video games and visual attention. (Green et al, 2003). Green et al, 2003 used an experimental study design to test the hypothesis that action video game players would have more improvement in visual attention scores as compared to a "placebo control" game. The video game that they used for control was the Tetris game. Their hypothesis was supported by their findings. In fact, action video game players (undergraduates, in their work) improved in a range of visual attention scores while Tetris players did not. Our current findings were contrary to what they found.

In the current study, older adults may have spent too much time trying to learn the action video game, specially the game interface. In other words, instead of practicing the dynamic

visual attention skills they needed to bolster, they were "stuck" at an earlier stage…spending too much time trying to figure out controllers and what steps to follow in playing the game. This would suggest that future video game training with older adults would need to (a) spend much more time on pre-training game orientation; (b) might need to select games with less complex interface learning; and (c) might need to spend much more time on game practice to achieve comparable effects to those seen with undergraduates. This latter point is underscored by the work of Charness Schumann, & Boritz (1992), who has reported on other computer learning tasks (e.g., word processing) that older adults need much more training time to achieve levels of performance comparable to that of younger adults.

Larger training dosages may be needed for adults of all ages - Above and beyond the unique challenges of training novice older adults how to play games, Green and Bavelier have themselves recently indicated that much higher training dosages (30 to 50 hours) may be needed to achieve optimal visual attention gains (Green and Bavelier, 2006c). The dosage in this study, nine hours, was based on the report of Green and Bavelier that ten hours of active play would be sufficient (for younger adults).

Poor selection of visual attention outcomes - A third possible explanation for the absence of MOH training effects may be related to the fact that past studies on video games have reported improvement in very specific aspects of visual selective attention (Green et al, 2003: & Green et al, 2006c), and the UFOV subtasks selected for this study may have insufficiently tapped these aspects of visual attention.

In more recent work, Green and Bavelier have begun to shift to other visual attention outcomes. While in previous studies they demonstrated that video game players outperformed non-players on different aspects of visual attention, they recently investigated the effects of video

game playing on individual differences in the number of simultaneous visual objects that could be readily tracked and attended to(Green et al., 2006a). Two outcome measures have had particular salience: 1) an enumeration task, in which participants have to report the number of briefly flashed items in a display as quickly and as accurately as possible and; 2) multiple object tracking, in which participants are required to allocate their attention to several (moving) items over time. Video game players showed enhanced performance on both tasks. These results suggest that future studies may consider broadening the set of outcome measures, which might be more sensitive to attentional gains produced by video game play than the task used in the current study.

Why did Tetris appear to have a stronger effect than MOH?

An unexpected finding in this study was that Tetris group participants experienced significantly more Selective Attention UFOV gain than no-contract control participants. Several possibilities exist to explain this effect. First, while Green and Bavelier (2003) showed that Tetris was not a sufficient challenge to boost dynamic visual attention in young adults, it may be that the whole-screen scanning and monitoring and mental rotation was a higher level of challenge (and therefore had training effects) for older adults, who were at a lower skill level. Expressed differently, during the Tetris game, participants had to look at pieces (tetraminoes) falling from the top of the screen while paying attention on the bottom of the screen, where they needed to place the pieces. While in studies with college students this stimulus was not enough to provide visual learning, perhaps this was a more optimal level of challenge for novice older adults. Second, because Tetris is a much easier game to learn and explain (the core game, rotating tetraminoes in order to make a flat line, did not become more complex over the course of training), participants may have "wasted" less time learning the game, and spent more of their

nine hours actively playing the game. The challenges of the Tetris game may actually have been more appropriate for elders' skill level.

What this speculation strongly suggests is that videogame training findings generated with younger adults may not be automatically generalizable to older adults. Much work must be done to identify the right game, the right level of challenge, the right sequence of training activities, the right outcome measure, and the right training dosage to optimize transfer for older adults.

Why was there no training transfer to any driving simulator outcomes?

Previous studies in the literature had shown that performance on the UFOV test is uniquely correlated with driving performance. Ball et al., 1993 found that visual attention measure was highly predictive of the self-reported history of older adults' crash problems. Goode et al., 1998 examined a set of neuropsychological measures thought to be related to crash risk in older adults and found that, of all cognitive tests administered, UFOV was most strongly related to crash involvement. Myers et al., 2000 found that UFOV was the best single predictor of an on-road driving test.

Given the fact that video game training improves visual attention (i.e., a UFOV-like task, according to Green and Bavelier), one might assume that playing a video game might enhance driving performance. In addition to driving competence, UFOV performance predicts important indices of mobility, including ambulatory ability, life space (the extent of travel throughout one's environment) and falls (Ball et al., 1993; Broman, West, Munoz, Bandeen-Roche, Rubin & Turano, 2004; Stalvey, Owsley, Sloane & Ball, 1999), suggesting further breadth of transfer possibilities.

In the current study, such transfer was not observed. However, there were differences between this study and previous work that help elucidate differences from previous studies.

First, in those previous studies where UFOV was predictive of driving, UFOV composite scores were used. In this study, training effects were observed at the level of specific subtasks (Selective Attention, Same-Different), and this may have meant that not a broad enough UFOV effect was achieved to obtain transfer, or the current participants may not have had much room for improvement in this test.

Second, our selection of driving simulator outcomes may not have been the right ones. One possible explanation for the lack of transfer of UFOV significant score to the driving simulator might be insufficient sensitivity to change in the driving simulator scores (i.e., brake reaction distance, lane maintenance, dog detection accuracy). Previous studies have found driving simulator tasks could be good proxies for visual attention (Roenker et al., 2003; Lee et all, 2003), and that UFOV improvement might also improve driving simulator performance, although they have used different outcomes as previously described. However, it is also important to note that the ACTIVE study failed to find evidence of UFOV transfer to any self-reported driving outcomes (simulator data were not collected; Ball et al., 2002)

Are group differences in Flow changes meaningful?

One area in which interesting training group differences were observed was self-rated Flow experience. The two game playing groups showed significant gain in Flow from the start to the end of training, while the traditionally trained UFOV group did not. This may have reflected the differences in training experience by group. Specifically, the UFOV training is highly repetitive. While training conditions change incrementally from trial to trial, the root task remains unchanged over the six sessions. Moreover, the interface is dated (black and white, text and two-dimensional icons). The interface is not very "game like", and so is not a source of fun/entertainment, unless participants enjoy the puzzle-like challenge of the task itself. In Tetris

and MOH, the interfaces were clearly games. For MOH, the significant difference between the first session and later sessions (which had significantly higher flow) may have reflected the initial confusion of learning the complex game. For Tetris, Flow gains were more gradual and incremental, and may have reflected participants growing sense of mastery of the game. This incremental gain in Flow for the Tetris group is consistent with the conceptions of Csikszentmihalyi's (1990) Flow Theory, which states that Flow is said to occur when people are able to meet the challenges of their environment with appropriate skills and accordingly feel a sense of well-being, a sense of mastery, and a heightened sense of self-esteem. Tetris appeared to be most likely to promote this sense of mastery.

Limitations

The present study used an innovative cognitive training strategy among older adults. The findings might contribute to the advances in the field of cognitive training and aging. Nonetheless, this study has several key limitations, owing largely to the constraint of resources and time constraints under which data was collected. One key limitation of this study is the sample. Specifically, participants who took part in this study were healthy, highly educated and Caucasian, which does not fully represent the broader American older adult population.

A second sample selectivity of the study relates to high participant function at baseline. According to UFOV normative data (Edwards et al., 2006), the participants from this study were already below the scores that their older peers normally have (i.e., were performing much better than the average older adult). Normative data indicated that adults with an average age of 74 years and who are highly educated (> than 12 years of education) have a mean score of 863.85 (UFOV composite score among the four subtasks). In this study, participants with similar demographic characteristics had a mean UFOV score of 704.48, which is much better than the normative data encountered for older adults at this age. This suggests that, on average,

participants did not have much room for improvement. Indeed, several UFOV training studies in Alabama, which had much larger UFOV training effects, selected participants with low performance at baseline (Ball et al., 2002; Edwards, et al., 2005). This suggests that the results of the current study may have shown somewhat weaker training effects than previous research both due to lower dosages of training (see below) and more advantaged participants. In addition, many participants reached ceiling performance on subtasks one and two (Speed, Divided Attention) of the UFOV test.

A third limitation of this study was the number of training sessions in which the participants were involved. Participant training was divided into 6 training sessions of 90 minutes each. Many times participants needed a break during the training, so that their cumulative training exposure could well have been less than 9 hours. As discussed earlier, since some of the training time was also spent learning the game (but not playing the game actively), the dosage of game play was likely well below optimal, especially for the MOH group.

A fourth limitation of the current study, which is also resource based, concerns the pool of trainers used in this study. With two exceptions, trainers in this study were volunteer undergraduate students who had responded to a flyer requesting students to help with this study. Although these students were committed to the study, they did not have any previous experience in training older adults. In addition, because of their school schedule, there were occasions in which a participant was trained by more than one trainer, which could have produced inconsistency in the training offered. In general, a professional staff of trainers, who consistently train participants, and who are monitored with regular quality control observations could serve to improve the effectiveness of training.

Another limitation of the study related to the invariant contrast of the presented dog (i.e., Dalmatian) throughout the scenarios. We did not assess contrast sensitivity at baseline, and so could not determine whether individual differences in this visual-perceptual attribute were responsible for individual differences in responding. Moreover, we did not vary the dog's perceptual features throughout trials, and so we could not determine whether more-or-less perceptible dogs would have affected responding.

In our assessment of flow and opinions about game design, we were unable (due to limited cell sizes) to contrast males and females. It is reasonable to assume, however, that there may have been gender differences in game acceptability and enjoyment. (For example, the military style violence of MOH may have been more unfamiliar to female participants than males; indeed, our participant comments about violence came from the women). Future research should more systematically sample males and females in order to examine gender differences in game response. It may be that different kinds of game design would be needed to optimally engage men versus women.

Another limitation to be mentioned is that, even though the brake reaction distance was correlated with the UFOV subtasks in this study (providing an empirical basis for expecting UFOV-related training gains to transfer), the selection of simulator outcomes in this study was idiosyncratic, and based on available data from the simulator program. To facilitate comparability with other research, it may make sense to develop a standardized set of simulator scenarios and outcomes that can be employed across training studies, and that are selected (in part) based on a known theoretical or empirical connection to the ability being trained. The current simulator outcomes had not been used in any previous training study with older adults.

Future directions

The current study confirmed the value of UFOV training for older adults, at least in terms of improving UFOV performance. The narrow band of transfer (e.g., no effects observed on a driving simulator) were disappointing, but consistent with the lack of transfer reported for UFOV training in much larger trials (see Willis et al., 2006). A promising initial finding was that participants in the video game groups (especially Tetris) experienced significantly more Selective Attention gain than no-contact controls, suggesting that there may be some visual attention benefits of videogaming in older adults. However, many questions were raised by this pattern of findings, and future research must clarify these.

First, future research should attempt to recruit samples of a more diverse population, with a particular emphasis on attracting participants with lower baseline function. It may also be sensible, in larger samples, to assess important potential covariates like socioeconomic status, medication use and health status at baseline.

Secondly, future studies should explore the impacts of larger dosages of training. Recent studies have suggested the need of at least 30 hours of training sessions to show major improvements in visual attention of undergrad students (Green et al, 2006c). It is reasonable to think that older adults would benefit from longer dosages of training. Indeed, a linear interpolation of the pre-post UFOV gain in the Tetris and MOH groups suggests that, with more exposure, these groups might eventually "catch up" to the UFOV trained group. The reality of this assumption needs to be tested, and the number of additional sessions needed to achieve larger UFOV effects must be determined. One reason we sought to explore commercially available video games was their "scalability"; i.e., these are low cost (under $200) interfaces that use televisions (already present in most homes). Thus, it would be quite feasible to place these devices in participants' homes, and to investigate much larger dosages. A secondary advantage

of exploring home-based training is that this better simulates "home based exercise", which has been shown to be effective (in the physical domain) in boosting the health of older adults. This is the ultimate goal of this line of research: to incorporate training in the everyday activities of older adults, and thereby naturally increase the dosage of training incorporated into elders' everyday lives.

Future research should also explore broader outcome measures. Green and Bavelier, in their work with younger adults, have been exploring broader outcome measures like enumeration tasks and multiple object tracking. These measures cannot be automatically used with older adults (they are quite difficult), and would need to be recalibrated for older users. However, with more specific tests for critical subcomponents of visual attention, the magnitude and breadth of videogame training could be better determined. It has been argued (Bavelier, personal communication, April 2007) that the UAB UFOV test (Ball, et. al., 1988) is a more global test and might not be able to capture the subtleties of attention changes produced by action videogame training.

Another area that needs to be investigated in future research concerns driving outcome measures. There are generally three outcome measures used in driving studies: driving simulator, behind the wheel assessment and archival crash records. A driving simulator program was selected for the current study because it constituted a safe way to collect driving data in an immediate time frame, while controlling visual attention demands in a systematic way. Behind-the-wheel assessments would have introduced potential safety concerns and difficulty controlling visual attention demands. Archival crash data would have required a much longer follow up period than the current study allowed, and who have been plagued by the potential reporting biases inherent in regulatory driving data. Although simulators seem like an ideal outcome

measure source for visual attention intervention studies, future studies using simulator outcome measures should explore developing and using standardized simulator scenarios and outcome measures, with pilot work identifying those simulator outcomes that are most 'saturated' with visual attention variance.

Another area for future research development is to better characterize progress in the games themselves. This has two benefits. First, if game playing proficiency can be reliably assessed, this would provide a better indicator of proximal outcome progress on the most direct target of training (i.e., game play). Secondarily, it would permit a better empirical estimate of how gains in game playing performance translate into gains in other outcomes. Third, better assessment of game playing performance would better permit adaptive customized training. If the level of game playing difficulty can be continuously calibrated to participants' current skill level, this would better permit the tailoring of game scenarios to match each participant's exact level of training need.

As has been stated several times in this document, our participants were positively advantaged. All were current drivers, and this may have restricted the amount of room for improvement that our sample had. Future research should also look at more restricted drivers (e.g., those constrained to only daytime driving, or driving in particular neighborhoods) or even drivers who have experienced recent license suspension for visual attention reasons. For these participants, with more potential room for improvement, the effect sizes of training like this may actually be higher, and the practical consequences of training might be greater: For such individuals, a question to be addressed with whether visual attention training might actually be able to help some individuals rehabilitate and recover their driving privileges.

Conclusion

Overall, the results of the current study suggested that UFOV training improved visual attention significantly more than any other group. However, it was noted that (although not significantly) the two video game groups experienced more visual attention gains than the no-contact control group. Actually, when the analysis was divided by UFOV subtasks, UFOV and Tetris (but not MOH) experienced significantly more gain than the no contact control group. Several factors might explain the reason why MOH gains were not replicated in this study such as possible insufficient dosage of training and the selection of outcome measures.

The results of this study also indicated that the visual attention gains, even after traditional UFOV training (which was highly effective), were not transferred to several simulator-based driving outcome measures. This might suggest that the simulator outcome measures used in the study were not sensitive enough to detect training-related changes. Future studies will need to more strongly develop a rationale for the specific outcome measures selected.

However, in contrast to absence of training transfer to simulator based measures, significant differences between training groups were observed in the session-to-session changes participants' Flow experiences. That is, analyses of self-rated Flow suggested that engagement improved over time for the two video game conditions but not for the UFOV training. This finding is also related to our results regarding participants' opinions about game design, in which participants affirmed their willingness to use this technology, and many perceived that the technology was a viable approach for "mental exercise".

Although this study did not provide conclusive evidence regarding the beneficial effects of video game interventions on older adults' visual attention performance, the preliminary data from this study "set the stage" for future research by indicating that (a) older adults enjoyed the video game training, and could be compliant with it, and (b) while video game training effects were not

significant, gain trends in visual attention were in the right direction. Linear interpolation suggests that with higher dosages, video game training may be more effective in boosting UFOV performance. This serves the ultimate goal of this line of research: to investigate the effectiveness of incorporating game-based mental exercise in the everyday activities of older adults.

APPENDIX A
MOH MANUAL GUIDE

MISSION 1

<Default settings should be:

- *easy play level*
- *vibration function off*
- *silver bullet on*
- *unlimited ammo on*
- *bullet shield on>*

<Need to show how to move forward>
<Need to show how to move right/left>
<Need to show how to hit and release "start" key>

- Go forward out of the bunk room and into the hallway ahead of you, with the flashing red lights and the sirens going on.

<Hit pause key>

<Need to show how to go right or left>

- Go right down the corridor, watching a fellow soldier get electrocuted by some stray wires that have been blown into a door jam.
- Don't stand too close to the wires or you will be electrocuted as well.

<Hit pause key>

- From there, look left and proceed forward into the shower room.

<Hit pause key>

- In the shower room, you'll meet up with another soldier who will tell you to follow him.
- If you do not meet the soldier, look right and pass into the toilet room.

<Hit pause key>

- If you saw the soldier, follow him as he goes into the adjacent room, and swing right into a hallway where you'll find a barber shop pole next to the door in front of you.
- If you did not find the soldier, look right into a hallway where you'll find a barber shop pole next to the door in front of you.

<Hit pause key>

- Ignore the room in front of you, look left, and move down through another corridor, where you'll see a man get blasted in the face with some extremely hot steam, falling to the ground.

<Hit pause key>

<Need to show how to climb stairs>

- Go up the stairs beyond him to the upper part of the USS California.

<Hit pause key>

<Need to show how to jump>

- Go forward, now, down the corridor to a pipe and some wires sticking out of the floor.
- The game will instruct you to jump over the pipes and wires, which you should do.

<Hit pause key>

<Need to show how to duck>
<Need to show how to stand up>

- Further up the corridor, you'll be instructed to duck under and walk below some pipes coming out of the ceiling.

<Hit pause key>

<Need to show how to press action button>

- At the end of this corridor, assist the engineer shut the door ahead of you by pressing the action button, taking care of an optional objective on this mission.

<Hit pause key>

● Then, look left and go up the stairs, getting closer and closer to the topside.

<Hit pause key>

- Once here, go left and move forward down a corridor, where a man will scream and run leftward down the corridor.

<Hit pause key>

<Need to show how to pick up fire extinguisher. Generally the fire extinguisher will be picked up automatically. If it is not found, move forward and backward into the corridor until you find it >

- Follow him as he approaches a fire down the corridor, grabbing the Fire Extinguisher automatically.

<Hit pause key>

<Need to show how to aim and spray fire extinguisher>

- Approach the fire in the immediate left and help him extinguish it
- Don't get to close. Fire hurts!

<Hit pause key>

- Proceed down the corridor to the first fire-engulfed door.
- Look left, use the Fire Extinguisher to take care of that fire.

<Hit pause key>

- Run into the room, taking out another fire as well.

<Hit pause key>

- Turn around, go back, now, to the previous corridor.

<Hit pause key>

- Look left, continue forward and extinguish the fire in the corridor.

<Hit pause key>

- Move forward, look left at second fire engulfed door, and take care of the fire.

<Hit pause key>

<Need to show how to hand fire extinguisher>

- Move forward entering kitchen. Approach the chef who is trying to put the fire out and hand him your Fire Extinguisher, which will allow him to put out the flames

<Hit pause key>

<Need to instruct in save points, and show how to save>

- Work your way forward and then right into the adjacent room.
- En route, as you're in the adjacent room, you'll see a save point (blue radiating light) that you can use to save your progress if you desire.

<Hit pause key>

- Turn around, move forward, look left (after the second pole) and you will see a door.
- Move towards the door and exit the cafeteria room.

<Hit pause key>

- Look left and move down the corridor to the staircase

<Hit pause key>

- Follow another staircase up, finally being topside on the USS California.

<Hit pause key>

- The soldier next to you will throw you a Browning Automatic Rifle LMG. This rifle can do some serious damage, but don't even bother with it.

<Hit pause key>

<Need to show how to switch to mounted gun as weapon>

- Quickly run up the set of stairs to the large mounted machine gun in front of you, using that as your weapon. Press action button.

<Hit pause key>

<Need to show how to fire and aim mounted gun>

- Using this massive gun (which has unlimited ammo), you'll want to shoot down as many planes as you can, as well as any torpedoes coming at your ship.

<Hit pause key>

- Play this part of the mission until you get really low on health, at which point you'll be knocked into the ocean water.

<Hit pause key>

MISSION 2

<Default settings should be:

- *easy play level*
- *silver bullet on*
- *unlimited ammo on*
- *bullet shield on>*

● Keep turning the turret and taking aim at the planes as they begin to swoop down from all directions.
<Don't bother aiming at the planes flying way high, as they are basically part of the background and can't be shot down>
<Hit pause key>

MISSION 3

<Default settings should be:

- *easy play level*
- *silver bullet on*
- *unlimited ammo on*
- *bullet shield on>*

- Run leftward to the end of the bridge. Follow your soldier companion, while avoiding running into fire.

<Hit pause key>

- Meet up your brother at the end of the bridge, who is kneeling behind a barricade.

<Objective completed>
<Hit pause key>

<Show how to aim>

- Stay behind the barricade and start shooting as many soldiers as you can.

<Hit pause key>

- Walk around and shoot the soldiers coming at you.

<Use your Thompson gun>
<Hit pause key>

< Change to the Garand gun>

- Direct your attention to the porch-like platform on the left side, where you will find a crouching Japanese soldier taking shots at you. Shot at him.

<Hit pause key>

<Show how to find surgeon pack, and medical kit>

- Focus on finding the various goods in the area.

<Hit pause key>

- Turn around and find a tank that needs to be fixed. It is near a staircase.
- Get close to the tank and it will say “Find Tank Coogwheel”.

<Hit pause key>

- Go to the back of the tank. You will see a staircase.
- Go Pass the staircase and enter the first left entrance.

<Hit pause key>

- Move towards the end of the room and, turn right.
- Move forward until you reach the wall, look right again and you will see the cogwheel on the floor.

<Hit pause key>

- Get close to the cogwheel and press the ACTION button.

<Hit pause key>

- Turn back, move around the crates. Leave the alcove.
- Turn right and go back to the tank.

<Hit pause key>

- Get close to the tank (left side) until it says “Press ACTION to fix Tank” on the top of the screen.
- Press ACTION button.

<The truck will clear a way into the Filipino village>
<Hit pause key>

- You should escort the tank by staying on the right side of it initially and follow it into the street beyond the barricade.
- You will see a Japanese soldier on the right side of a porch. Shoot at him and continue moving forward.

<Hit pause key>

- There will be two more Japanese soldiers in an alcove ahead on the right side. You should shoot them.

<Hit pause key>

- Move forward with the tank as it heads left, down the next street.
- If you need health, grab the **Field Surgeon Pack** on your right as the tank turns left.

<Hit pause key>

- Suicide soldiers will run at the tank with explosives, shoot them.

<Hit pause key>

- Continue up this street towards a decorative fountain on your right.
- Shoot at any Japanese soldier as you go, including the suicide bombers.

<Hit pause key>

- Go forward, and let the tank turn right again.

<Hit pause key>

- Follow the tank down. There won't be too many enemies as you go.
- In case you need health, you should shift right into a building as you're going to grab a **Field Surgeon Pack** to heal yourself if need be.

<Hit pause key>

<As the road turns left once more, the tank will stop>

- There will be one Japanese soldier on your right. Shoot him from the street.

<Hit pause key>

- There will be two Japanese soldiers on your left. Get closer to them and shoot.

<Hit pause key>

- Go back to the tank's position on the street as it now heads down yet another road.

<Hit pause key>

- Continue following the tank until it stops at a forced-dead end made from rubble.

<Hit pause key>

- Go slightly behind the tank and to the right, you will find a staircase leading up.
- At the top of this staircase, the door is locked, but you will find a **Field Surgeon Pack** if you need it.

<Hit pause key>

- Backtrack all the way to the vacant road before this small complex of houses.
- You will find soldiers as you come back, you should shoot them.

<Hit pause key>

- Move toward the tank.
- From the tank, make a left and move forward all the way to the end.

<Hit pause key>

- Turn right and move toward the building in your left with smoke.
- Shoot at the soldiers in front of the building.

<Hit pause key>

- You will find that the building has a door that's not closed anymore, but now blown open.
- Run at the door and enter into the building.

<Hit pause key>

- You will see a staircase in the initial room in this building.
- Behind the staircase is a save point. Get close to the blue radiant light and save the game.

<Hit pause key>

- Go up the staircase.

<Hit pause key>

- Move forward on to the plank into the new room.
- Go through the hole in the wall to an outdoor destroyed half-room of this house.

<Hit pause key>

- Go down using another plank.
- You will find yourself outside the building and on the street again.

<Hit pause key>

- Shoot the Japanese machine gunner.

<Hit pause key>

- Get close the machine gun and mount it, pressing the ACTION button.

<Hit pause key>

- You will see soldiers coming from your right and left side. Shoot them.

<Hit pause key>

- Dismount the machine gun by pressing the ACTION button.

<Hit pause key>

- Turn right onto the street.
- Look right and follow the street.

<Hit pause key>

- Turn left at the bend in the street.
- Proceed forward until you see a huge wooden brown gate on the right hand side.
- Shoot all enemies.

<Hit pause key>

- Look directly at the gate. On the right and left hand sides of the gate on the floor, there are sewers.
- Approach the right sewer gutter on floor and follow it down.

<Hit pause key>

- Turn left into the sewer.

<Hit pause key>

- Press crouch button and turn right.

<Hit pause key>

- Proceed forward into the sewer.
- After the sewer, press the crouch button again, which will make you stand up again.

<Hit pause key>

- Look right into sewer. Follow the right path when the sewer path splits.

<Hit pause key>

- There is a staircase at the end of the path.
- Proceed up the staircase.

<Hit pause key>

- You will see enemies coming in your direction. Shoot the enemies.

<Hit pause key>

- Look right and proceed forward along the wall to the right. Follow this wall until some bleachers are reached.

<Hit pause key>

- Go up the stadium stairs.

<Hit pause key>

- Once on the top of the stairs, look left and you will see a booth with a radio operator.
- Enter the booth and shoot the radio operator.

<Hit pause key>

- Turn around and exit the radio post.
- Look right and proceed forward down the stairs.

<Hit pause key>

- You will see a brown door at the other side of the stadium.
- Once you get close to the door, it will open automatically. If the door does not open, move around in the open area in front of the door.

<Hit pause key>

- Shoot the soldiers in front of you.

<Hit pause key>

- Move in the direction of the gates that were previously closed.
- Turn right.

<Hit pause key>

- Make a left at the bend of the road and look for a hotel-like building ahead of you.

<Hit pause key>

- Proceed into the building.
- Look left and enter into the adjacent room.

<Hit pause key>

- You will see a staircase.
- Climb staircase.

<Hit pause key>

- Make a right and follow through doorway.

<Hit pause key>

- Go left and up the stairs.

<Hit pause key>

- Make another left and go to rooftop.

<Hit pause key>

- Once you get to the rooftop, approach the machine gun.
- Press ACTION button to mount the machine gun.

<Hit pause key>

- Destroy the tank and crates in the middle of the town square with the machine gun.

<Hit pause key>

- Press ACTION button and dismount the machine gun.

<Hit pause key>

- Turn around and enter into the doorway.
- Go down the first set of stairs.

<Hit pause key>

- Go down the next set of stairs which will lead you back to the lobby of the hotel.

<Hit pause key>

- Enter the doorway and look left.

<Hit pause key>

- Proceed forward through the metal gate and into the courtyard in front of you.

<Hit pause key>

- Proceed forward towards the fountain.

<Hit pause key>

- Move towards the truck at the far end of the courtyard in your right.
- Reach the front of the truck.
- A soldier will automatically greet you.
- Locate the lost explosives truck objective completed.

<Hit pause key>

- Turn around. Proceed forward a few steps and look left.
- You will see a church.

<Hit pause key>

- Enter the church steeple.
- Proceed forward.

<Hit pause key>

- Look right and find the radiant blue light.
- Move toward the light.
- Press ACTION button in front of it to save game.

<Hit pause key>

- Turn around and proceed toward the back of the room.

<Hit pause key>

- Look left and climb the staircase to the top of the steeple.

<Hit pause key>

- At the top of the staircase, follow a path around to the end of the platform.

<Hit pause key>

- Look left at the bells.
- Press ACTION to ring the bells.

<Hit pause key>

- Turn around and go back down to the bottom of the stairs.

<Hit pause key>

- Look right and proceed forward through the archway and exit the church.

<Hit pause key>

- Look right and proceed toward the truck.

<Hit pause key>

- Make your way towards the back of the truck.
- Face the back of the truck and press ACTION to board the truck.

<Hit pause key>

- The truck will automatically start up.
- Turn around and shoot the soldiers.

<Change to Thompson gun >

<Hit pause key>

- Using your guns and grenades take out attacking enemies.

<Hit pause key>

- Destroy the tank by throwing grenades at it or by throwing them on the ground where the tank will pass over.

<6 grenades hit will destroy the tank>.
<Hit pause key>

- Keep firing enemies until the truck comes to a stop.

MISSION COMPLETED!!!
<Hit pause key>

MISSION 5

<Default settings should be:

- *easy play level*
- *silver bullet on*
- *unlimited ammo on*
- *bullet shield on>*

<As you begin the mission, you will be on a pre-blazed jungle path.>

- Go forward a bit until the path widens and follow the brown path ahead until you meet up with a trio of Japanese soldiers.
- Shoot the enemies here.

<Hit pause key>

- Go forward from there, and the path will swing rightward.
- Here you will see a light brown tree with root coming up from the ground.

<Hit pause key>

- Move towards the left side of the tree. Look right and pick up two Garand clips positioned around a campfire on the ground.

<Hit pause key>

  - Go pass the campfire and approach a narrow tree trunk. Look left.
  - Shoot at the Japanese soldiers surrounding the ridge in front of you.

<Hit pause key>

- Once the path is clear, you can grab some **M1 Garand Clips** and a **Medical Kit** on the ridge they were guarding.

<Hit pause key>

- Work your way rightward – you will hear the pounding of a mounted machine gun here.
- Follow your compass North and find the mounted machine gun shooting at you.
- Shoot at the enemy on the machine gun.

<Hit pause key>

- Mount the cleared off-mounted machine gun and use it to clear the Japanese soldiers ahead.

<Press action button to mount the machine gun>
<If you hit any of the rebels, you won't damage them> <Make sure the Japanese soldiers are all dead before continuing>
<Hit pause key>

- Approach the rebels, who are accompanied by an allied officer. He'll talk to you briefly, and then lead you to a small hideout that the rebels have near there.
- Follow the allied officer to the hide out.

<Hit pause key>

- Go straight ahead down the cave-like path, where you'll find a **Field Surgeon Pack**, some **M1 Garand Clips** and **Grenades**.

<Hit pause key>

<At the end of this linear, dead end path, you'll find a save point as well, where you can save your game>
• Get close to the blue radiant light and press action button to save the game.
<Hit pause key>

- Go back down the path and make a left at an opening in the cave like path.
- Head up this linear pathway, coming back up outside.

<Hit pause key>

- Once outside, approach the allied officer again, and he'll tell you to look ahead for the lost Allied patrol that we were looking for.

<They are being heavily guarded by Japanese soldiers, so we're going to need to approach with caution here. >
<Hit pause key>

- Get as close as possible to the Japanese soldiers holding up the Allied prisoners as possible, and begin to fire away.

< Be cautious of a sword wielding officer who can inflict massive damage up close. He will come after you if you get too close to the prisoners.
<Hit pause key>

- Use the cover in the area (preferably staying in the shrubs to keep a low profile) and pick away at the soldiers as they come.
- Eliminate all enemies in the area.

<When the Japanese soldier is dead, the Allied Patrol is automatically 'rescued'">
<Hit pause key>

- You will need to walk behind the three Allied prisoners, now, and untie each of their hands when the on-screen prompt tells you to.

<Walk behind the poles and press action button>
<Hit pause key>

- Talk to the prisoner in the middle, and he'll tell you that he and his crew were sent to take care of Pistol Pete, but were captured. They want to join your group and help you do the job, now.

<Hit pause key>

< From there, the rescued prisoners grab their guns off the porch of the house behind them.>

- You can grab two boxes of **M1 Garand Clips**, from that same porch as well.

<Hit pause key>

- Go behind this house and you will see a small ditch underneath.

<Hit pause key>

- If you go in a crouch, you will be able to crawl into this little area and grab the coveted **Machete** here.

*<Using the **Machete**, we'll now be able to take shortcuts and the life from here on out, through the rest of the missions in the game.>*
<Hit pause key>

- Turn around, move forward and stand up.
- Look left and go around the house until you see break in the fence on the right.

<Hit pause key>

- Approach the break in the fence.
- Follow the fence up the grassy hill.

<As you go up this heavily-wooded hill, eliminate all Japanese soldiers. Because of the incline of the hill and the close quarters, you should use the M1911 as your weapon.>
<Hit pause key>

- Approach the top of the hill on the left side where the fence ends.

- You will see some bushes here that do not let you move forward.
- Use the Machete to clear the path.

*<Press action button to use the **Machete**>*
<Hit pause key>

- Run down this initial linear path beyond the bushes we just cut, picking up a **Medical Kit** and some **Garand M1 Clips** en route to another bush, which we need to cut out of the way.

<Hit pause key>

- Beyond these second bushes, you'll follow another linear path to the third bush we need to cut.
- Use Machete to cut these bushes as well.

<Hit pause key>

<Beyond this, the pathway opens up again>

- Run left up the hill there, shooting enemies with your **M1911** as you go.

<Hit pause key>

  - You'll eventually see a huge gun installation, the Howitzer, on your right surrounded by Japanese soldiers.
  - Shoot at the Japanese soldiers surrounding and on the gun.
  - Man the Howitzer.

<Press action to man the cannon>
<Hit pause key>

- Shoot at and eliminate all enemies.

<Show how to use Howitzer>
<The Howitzer packs a powerful punch with the explosions it causes, but it takes a while for it to reload, so carefully fire it as to not miss and pay the price. Don't aim directly at enemies, but rather aim at the ground surrounding a certain amount of enemies to do the ultimate amount of damage you can.>

- A tank will come at you, eventually (by your left side), which you'll need to eliminate. Two or three well-aimed, quick Howitzer shots should do the trick.

<Hit pause key>

<Press action to dismount the cannon>

- When things calm down around the huge cannon, collect the **M1 Garand Clips** around the gun, as well as the numerous items the dead enemies undoubtedly left behind as well.

<Hit pause key>

- Run straight down the hill now (in direct line-of-sight of the Howitzer) and, across the road at the bottom of the hill, you'll find two **M1 Garand Clips.**

<Hit pause key>

- Run leftward down the path, and go down the linear direction it leads until you come to a turn in the road that puts you in the direct sight of a Japanese soldier manning a mounted machine gun.

<Hit pause key>

- Run towards his gun and jump over the barricades surrounding the gun to find some **M1 Garand Clips.**

<Hit pause key>

- Look across the tiny river to kill two more Japanese soldiers standing by a second machine gun.

<Hit pause key>

- Go across the bridge to the other side of the river, and over to the location of the two Japanese soldiers we just killed, behind the second mounted machine gun's position. You'll find a **Medical Kit** here.

<Hit pause key>

<Press action to mount the machine gun>
<Show how to use machine gun>

- Man the second mounted machine gun there and wait for the soldiers to run down the path to your right.

<Hit pause key>

<Press action button to dismount the machine gun>

- Go back on the path in front of the bridge and continue up a short ways until the path forks.
- Take the right fork, which soon thereafter leads to a dead end.

<Hit pause key>

<At this dead end, however, you'll find a save point, as well as a Field Surgeon Pack, M1 Garand Clips, and some Grenades.>

- Save the game
- Grab the goods
- Head back to the main path, where the fork was. This time go right.

<Hit pause key>

- You'll meet up with two enemies hidden behind a ridge and one who pops up from the ground.
- Shoot at these enemies.

<Hit pause key>

<Beyond them, you'll come to a hilly clearing where you'll have to fight a slew of Japanese soldiers, both out in the open initially and hiding in the ground, waiting for you to come towards them before surprising you>

- Take out all enemies.
- Go up the ridge on the right side of the clearing to find a **Medical Kit**.

<Hit pause key>

- Proceed forward down the ridge and continue forward to the path in front of you.

<Hit pause key>

- From there, you'll want to continue down the linear path beyond this opening, killing any more enemies you come across.

<Hit pause key>

<You'll run into more enemies as you go, but eventually, you'll come to another small river. Across the river and to your right, you'll find Japanese soldiers shooting on some rebel soldiers and the like from across the river>

- Join in on this battle, eliminating all Japanese soldiers on the left side of the river.

<Hit pause key>

- Lob some Grenades or fire away at the rest of the soldiers in the area across the river as you go right and run into Martin Clemens, the Allied officer who is with the local rebel force.

<Hit pause key>

- Talk to him, and he'll tell you to continue your quest, automatically giving you first the Thompson M1 SMG to equip yourself with if you so desire.

<Hit pause key>

- From where you meet up with him, first go backwards to a small overlook area, where you'll find a **Medical Kit**.

<Hit pause key>

- Turn around, cross the river and proceed down the path beyond it.
- Eliminate all enemies along the way.

< Watch out for kamikaze attacks from the enemies >
<Hit pause key>

- Kill these enemies, and then bear right and up a small hill to the position of an enemy sniper we killed earlier, when we were on the other side of the river.

<Hit pause key>

- Up here, you'll find two boxes of **M1 Garand Clips,** and a **Medical Kit** as well.

<Hit pause key>

- Go back down the small hill to a fallen tree trunk.
- Jump over it and continue up the start of a narrow path, killing Japanese soldiers as you proceed.

<Hit pause key>

- When the path forks ahead, go left and down a small, linear, vacant path.

<Hit pause key>

<It will lead you to a cave entrance>

- Enter into this cave and follow the linear maze of crates as you go forward.

<Hit pause key>

<You'll eventually come to an area where Japanese resistance will start to show up>

- Kill one Japanese soldier on the ground.

<Hit pause key>

- Look up the path going up in that room to fire on two or three more soldiers.

<Hit pause key>

- When all enemies are dead, go up this path and it'll lead to another cave, which overlooks the area below with a huge Howitzer.

<There will be four Japanese soldiers around this gun, in addition to a Japanese officer>
<Hit pause key>

- Kill off all five enemies with some quick fire from your **Thompson**, and then collect the various goods around the gun.

<Hit pause key>

- One of your accompanying soldiers will automatically set up an explosive on the large gun and allow you to set if off.

<Hit pause key>

- Before you do so, look behind the gun to find a little out-of-the-way branch to this cave, where you'll find a save point as well as a **Medical Kit** and some **M1 Garand Clips.**

<Hit pause key>

- Save your game, grab the goods
- Use the detonation box attached to destroy the gun.

<Turn around>
< the detonation box that will be in your left>
<Press action to use detonation box>
<You'll have to be behind the crates>
<Hit pause key>

- From here, go towards the gun and look left for a door out of this room.

<Hit pause key>

- Go through this door, and down a pathway, killing pistol-wielding Japanese soldiers as you come to an open room in this cave with a wooden bridge suspended over it

<Hit pause key>

- Cross the bridge.
- At the end of this bridge you'll find a Japanese soldier. Japanese soldiers are all over the bottom of this room as well.

<Hit pause key>

- Kill the soldier(s) on the bridge, then simply fall down to the ground below, taking out any remaining foes.

<Hit pause key>

- With all of the Japanese resistance in the room dead, go right and head back outside.

<Hit pause key>

- Once out here, go leftward towards the bridge leading over the gigantic chasm ahead of you.

<Hit pause key>

- The enemy resistance here will be almost exclusively on the other side of the bridge, so run across this bridge, taking out the enemies there.

<Hit pause key>

- On the other side of the bridge, to your left, you'll find some **Grenades** and a **Thompson Magazine**, while on the right side of the bridge once you cross it, you'll find a **Medical Kit** and some **M1 Garand Clips**.

<Hit pause key>

- From here, climb up the large staircase ahead of you to the ridge above, killing any remaining enemies as you go.

<Hit pause key>

- Once up the stairs, move right and do a full charge towards the room ahead of you with a mounted machine gun sticking out of it.

<Hit pause key>

- Make sure to quickly shoot the enemy at the machine gun before he opens up on you, as well as the soldier accompanying him.

<Hit pause key>

- When you do, the door leading into that room will explode open, granting you access.

<Hit pause key>

- Grab the M1 Garand Clips near the mounted machine gun.

<Hit pause key>

- Bear right into the next room with the Howitzer within.

<Hit pause key>

- Kill the Japanese officer and the two Japanese soldiers before proceeding into that room.

<Hit pause key>

- As you walk into the room, grab the **M1 Garand Clips** and the **Thompson Ammo** as your partner sets explosives on the Howitzer.

<Hit pause key>

- When your partner runs behind some crates to watch the Howitzer explode, you should do the same.
- When the gun explodes, look to the door at your left, leading out of the room, where a Japanese soldier or two will run into the room, gunning at you.

<Hit pause key>

- Kill these enemies and proceed out of this room, to the corridor beyond the door.

<Hit pause key>

- Run down this corridor, guns blazing, as you come across the last resistance of Japanese soldiers in this cave system.

<Hit pause key>

- When you can either go right, or go forward, go right, kill the enemies in this room, and quickly run up the stairs to your right, and up to the final Howitzer in the area.

<Hit pause key>

- Your partner will explode the gun, and when that happens, you're able to run out of the door to the left of the now-destroyed gun, and back outside.

<Hit pause key>

- Once outside, run leftward towards the bridge, killing the Japanese soldiers as you go.

<Hit pause key>

- Cross the bridge to find some of your rebel friends and the rebel Allied officer as well.
- En route, however, your colleague will trip while he is planting some explosives on the bridge

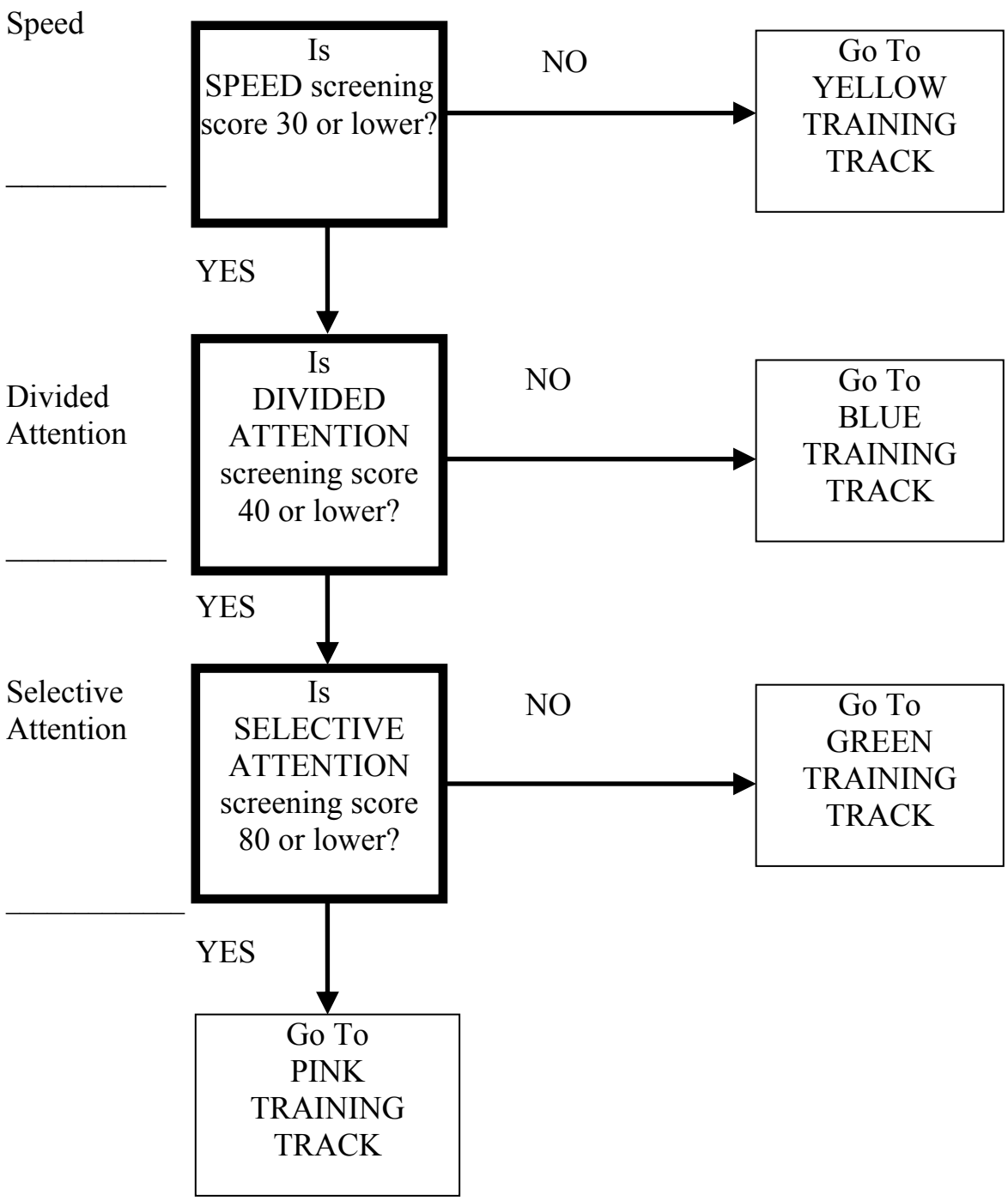
<Hit pause key>

- Stop and grab him by facing him and pressing action to complete the second of two optional objectives on this mission.
- Get over the bridge thereafter.
- After a set amount of time, the bridge will explode.

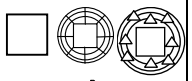
MISSION COMPLETED!!

<Hit pause key>

Start Point for Customized Training



ID_____Training Track Color_____Computer System Number _____

	Sess	Task  Easy ---→ Hard	Center Task Easy----------→Hard	Duration Hard----------→Easy	Ring Easy---------→Hard	Block1	Block2	Block3	Block4	Block5	Block6	Notes
1		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
2		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
3		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
4		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
5		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
6		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360	Inner Middle Outer							

				400								
7		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
8		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
9		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
10		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							
11		Speed Div Sel	P/A I SD A	40 80 120 160 200 240 280 320 360 400	Inner Middle Outer							

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BIOGRAPHICAL SKETCH

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