View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by University of Central Florida (UCF): STARS (Showcase of Text, Archives, Research &...

University of Central Florida
STARS

Electronic Theses and Dissertations, 2004-2019

2012

Analyzing Action Game Players' Performance During Distracted Driving

Michael Rupp
University of Central Florida

Part of the Psychology Commons
Find similar works at: https://stars.library.ucf.edu/etd
University of Central Florida Libraries http://library.ucf.edu

This Masters Thesis (Open Access) is brought to you for free and open access by STARS. It has been accepted for inclusion in Electronic Theses and Dissertations, 2004-2019 by an authorized administrator of STARS. For more information, please contact STARS@ucf.edu.

STARS Citation

Rupp, Michael, "Analyzing Action Game Players' Performance During Distracted Driving" (2012). *Electronic Theses and Dissertations, 2004-2019*. 2241.
https://stars.library.ucf.edu/etd/2241

University of Central Florida
STARS
Showcase of Text, Archives, Research & Scholarship

ANALYZING ACTION GAME PLAYERS’ PERFORMANCE DURING DISTRACTED DRIVING

by

MICHAEL RUPP
B.S. University of Central Florida, 2009

A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
of Modeling and Simulation
in the College of Graduate Studies
at the University of Central Florida
Orlando, Florida

Summer Term
2012

Major Professor: Janan A. Smither

© 2012 Michael A. Rupp

ABSTRACT

Driving is a complex task that is highly reliant on attention. Research states that distractions cause performance errors thus it is important to find ways to reduce driver distraction or assist drivers with ways to improve their cognitive resources if distraction is unavoidable. Moreover, research indicates that action video game players outperform non-players on lab-based tests of visual and cognitive abilities. However, research also exists that is contrary to these findings. Some researchers suggest that methodological deficiencies could be the cause of the significant findings in the literature. With such fervor of debate on the subject, the question remains of whether players acquire skills through playing action video games and if so can these games be used as research or training tools to enhance performance on realistic tasks. To answer this question, 45 male participants were tested using psychometric measures of spatial ability (Spatial orientation and visualization) and failures of attention (Cognitive Failures Questionnaire), and then all participants drove four 10-minute drives in a driving simulator. The first drive was a practice, followed by a control drive. Participants were then distracted using a hands free phone conversation. Following that, participants completed a final control drive. Both overall video game experience and action video game experience was positively related to higher spatial ability scores. Additionally, participants with higher action game experience exhibited fewer lane deviations during driving overall, but not during the distraction condition. On the other hand, participants with higher spatial ability scores exhibited fewer lane deviations during the distraction condition, but not during the control drives. Furthermore, action video game experience was not significant on the Cognitive Failures Questionnaire. Therefore, it was concluded that individuals who have higher action game experience do not show improvements on any abilities of attention tested in this study. However, higher experience action video game players may perform better in simulated environments than those with less experience.

ACKNOWLEDGMENTS

To begin, I would like to thank everyone that assisted me in the creation of this document. I cannot completely express how grateful I am for all the help I received from the members of my thesis committee. Without the guidance, knowledge, time, and assistance of Dr. Janan A. Smither, Dr. Mustapha Mouloua, Dr. Daniel S. McConnell, and Dr. Peter Kincaid, the process of completing my thesis would not have been an easy one. Their help and dedication to my research efforts were greatly appreciated. I would also like to thank Dr. Mouloua for the use of his driving simulator, which I used to conduct my study. Next, I would be remiss if I failed to thank my fellow lab mates in the Technology and Aging Lab for their comments, concerns, and otherwise witty insights and challenges to my research, which made my arguments stronger and more defendable. I would like to thank both Jessica Michaelis and Marc Gentzler for their enthusiasm of looking over countless drafts of my research and taking the time necessary to provide me with insightful comments. Finally, I would like to thank my entire family for their continued support and encouragement throughout my educational career.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ASRS	Adult Symptom Response Survey
AVG	Action Video Game
CFQ	Cognitive Failures Questionnaire
DHQ	Driving Habits Questionnaire
DPQ	Demographic Phone-Habits Questionnaire
ESA	Electronic Software Association
FMRI	Functional Magnetic Resonance Imaging
MHQ	Motion History Questionnaire
NASA-TLX	National Aeronautics and Space Administration Task Load Index
PET	Positron Emission Tomography
PFT	Paper Folding Test
PHQ	Phone Habits Questionnaire
SA	Situational Awareness
SO	Spatial Orientation
SSQ	Simulator Sickness Questionnaire
SV	Spatial Visualization
UFOV	Useful Field of View
VGQ	Video Game Experience Questionnaire

CHAPTER ONE: INTRODUCTION

Researchers have been studying human attention since the days of William James (1890). Throughout this time, researchers have discovered that attention is a limited resource and thus humans can only attend to a limited number of items at one time (Regan, Young, & Lee, 2009). When multiple items are present, an individual must select which items to allocate his or her attention. This process occurs as both a bottom-up and top-down process. Bottom-up processes are stimulus driven where characteristics of the signal such as color or intensity affect the saliency of the stimulus. Top-down processes utilize memories and experiences to determine if a stimulus is important or not (Parasuraman & Davies, 1984; Pashler, 1998). An example of bottom-up processes is focusing on a light along the highway because it is the most salient object present, which has been a hypothesis of some late night traffic accidents (Wallace, 2003). An example of top down processes is shown by experienced drivers. As drivers, learn where hazards occur around their vehicle, eye movements become concentrated toward the center of the visual field and around potential hazards, instead of randomly around the visual scene (Wallace, 2003).

Driving is a complex multifaceted activity composed of many subtasks (cognitive, visual, auditory, and manual) and as such it is one of the most complicated tasks that humans typically perform (Gentzler & Smither, 2012; GHSA, 2011, Regan, et al., 2009). Research on driving safety has existed for at least 55 years, with an emphasis on the attentional demands of driving. Studies have also emphasized ways distraction can negatively affect performance (Buck, 1957; Lee, 2008). In the last 30 years, researchers have focused on the impairment associated with specific devices that drivers may use while operating a vehicle (Lee, 2008). The consensus is that the resources needed to complete multiple driving-related tasks are limited and as additional tasks such as phone, conversations are introduced, driving performance declines (GHSA, 2011; Regan, et al., 2009).

The topic of distracted driving and mobile phone use has increased in importance in recent years as owning a mobile phone has become more pervasive in society (Palen, Salzman, & Youngs, 2000). A number of recent studies have investigated the effects of driving while using mobile phones (Caird, Willness, Steel, & Scialfa, 2008; Strayer & Johnston, 2001; Strayer & Drews, 2007). An additional meta-analysis of over 47 driving studies provides evidence for the deleterious effects of this type of distraction (Horrey & Wickens, 2006). Madden and Rainie (2010) surveyed 2,252 adults age 18 and over and 75% of the respondents reported using a phone while driving. Another survey of 6,002 adults over the age of 18 indicated that 66% of those respondents would answer an incoming phone call and continue to drive as opposed to stopping to answer the call or declining the call. Seo and Torabi (2003) surveyed about 1,185 college students, 86% of whom had mobile phones and reported that they talked on their phones while driving. Of these respondents, over half reported having an automobile crash or near miss in which at least one of the drivers was talking on a phone at the time of the crash.

The accumulation of this research illustrates the need for driver interventions to help reduce the crash rate of drivers distracted by mobile phone use. A study by Walsh, White, Hyde,

& Watson (2008), conducted five years after the previous work by Seo and Torabi, also showed similar results.

Legislative interventions aimed at controlling or banning the use of mobile phones while driving have fallen short. As of April 2011, not a single state had banned all mobile phone use unequivocally for noncommercial drivers (GHSA, 2011). However, even a complete ban may not eliminate the phenomenon of mobile use while driving.

A lack of attentional resources has been cited as the reason for distraction (Strayer, 2001; Strayer & Drews, 2006; Horrey & Wickens, 2003). In order to find interventions that will reduce crash risk in spite of unchanging phone use, it is perhaps helpful to look at expert populations who may possess certain skills that improve their abilities in attention-demanding tasks (Green & Bavelier, 2006; Bavelier, 2011). One such population is action video game (AVG) players. Studies have shown that people who play action games are more likely to perform both divided and selective tasks of attention better than non-players (Green & Bavelier, 2003; 2006). The researchers claim that AVGs require heightened attentional skills and that these skills can transfer to activities performed outside of the game (Green & Bavelier, 2003; 2006). At the center of this claim is the observation that AVG players have more cognitive resources, which may ameliorate effects of phone-induced distractions while driving (Green & Bavelier, 2003). However, additional studies have shown data, which are contradictory to the claim that both playing AVGs have an effect on attention, and that positive skill transfer can be achieved through their use. Both methodological and self-selection issues have been raised in regards to the action game literature (Boot, Kramer, Simons, Fabiani, & Gratton, 2008; Boot, Blakely, & Simons, 2011). Therefore several questions remain. Primarily, are AVG players better due to a skill acquired through gameplay, or are the skills a result of a trait that increases the likelihood that individuals play AVGs? Secondarily, in spite of the incongruous results do these skills transfer to increased performance while driving an automobile?

Within the United States, there is a large population of people who already play video games. The Entertainment Software Association (ESA, 2010) claims that over 66% of all Americans play video games and that the sales of software generated over $10.5 billion in 2009. In addition, playing video games is not limited to one age group. The average player is 34 years old and 26% of people over age 50 play games. Both sexes play games with over 40% of players being female. In addition, of all the games sold in 2009, 38% were action games (ESA, 2010).

Therefore, if skill improvements are due to gameplay and are transferrable to other tasks then researchers may be able to incorporate such benefits of game play to increase existing training. Kato, (2010), and McKay and Maki (2010), have suggested that video games are useful for educational purposes; by increasing motivation and adherence to training compared to traditional classroom methods.

CHAPTER TWO: LITERATURE REVIEW

Information Processing

Wickens and Hollands (2000) outlined one model of human information processing. This model has five main stages (sensory processing, perception, response selection, response execution, and feedback). First, sensory receptors transduce stimuli into neural activity that is sent to the brain for processing (Green, Allen, Abrams, & Weintraub, 2008). This stage of processing includes an initial short-term sensory store in which the sensory information is held briefly (as short as a half of a second) before it moves onto the processing stage (e.g., Sperling, 1960). The second stage is perception, during which it is theorized that the raw sensory information is organized into a meaningful percept. This processing is automatic and sensory information takes no effort to process (Wickens & Hollands, 2000). Once perception occurs, the information is held in working memory for as long as the individual uses attention to keep it active. The next stage is response selection; where decisions are made based on the information. However, before this can happen an understanding of the situation must be achieved (Endsley, 1995; Wickens & Hollands, 2000). In this stage, the individual must recall information from long-term storage into working memory, make a decision, and execute the response. Finally, the results of the action are perceived, providing potential feedback for guiding a corrective action. Attention is required at the key stages of perception, response selection, and feedback processing (Wickens & Hollands, 2000, but see also Saunders & Knill, 2003) Failures of attention may lead to a failure to encode information about the environment, inappropriate response selection, inaccurate responses, or failure to correct ineffective responses.

Attention

Attention is the process of exerting effort in order to process stimuli in one's environment and there are several types or attention. First, sustained attention is the ability to attend to a stimulus over a period of time (Parasuraman & Davies, 1984). Second, selective attention is the ability to choose stimuli which to attend, while ignoring others. Finally, divided attention is the process of attending to two or more stimuli (Parasuraman & Davies, 1984; Pashler, 1998).

Capacity Model of Attention

Currently, there are several types of theories of attention: capacity theory models and bottleneck theory models. Capacity models hold that attention is limited by capacity and there is a central reserve of resources, for which attention-driven activities compete. Each task may require a certain amount of resources and we can allocate resources to complete these tasks. Performance decrements occur when insufficient resources are allocated to a task (Kahneman, 1973).

Bottleneck Theory of Attention

Bottleneck metaphors of attention stem from the idea that information processing is serial and can only proceed by processing a single or limited number of tasks at once. Competing theories suggest the bottleneck occurs after sensory processing (Deutsch, 1963). In this case, stimuli can be processed in parallel but choosing among multiple responses is a serial task that increases in duration as a function of decision complexity. The Central Bottleneck theory proposed by Wellford (1967) used dual task methods to measure the psychological refractory period during which information processing is delayed. Pashler, Johnston, & Ruthruff (2001) noted, however that practice can reduce the duration of certain processing stages, which may reduce the bottleneck effect.

Automatic and Controlled Attentional Processes

Human performance depends on two attentional processes. These two processes directly affect an individual's attentional capacity to complete tasks. Schneider and Shiffrin (1977) originated the two-process theory defining that processing can be either automatic or controlled.

Automatic processing tasks are effortless. These tasks do not require any attentional resources. Examples of these tasks are breathing, chewing gum, and performing a well learned task. These tasks can be learned automatically through extensive training and they require constant responses to stimuli at every occurrence of the stimuli. Automatic processing is unaffected by distracters, memory, or limits of attentional or cognitive capacities. These processes are faster than controlled processes. However, these processes are also difficult to suppress, alter, ignore, or suppress once they are learned to the point of automaticity (Fisk & Schneider, 1981; Schneider & Shiffrin, 1977).

Controlled processes are not automatic; they require access to working memory, attention and other cognitive resources. These tasks are serial and slow; distractions can greatly impair these tasks since they are capacity limited and require effort. These processes can be ones that are not extensively trained or novel tasks, or they can be tasks that are very complex that they cannot be automated. Controlled tasks are also easily altered, reversed, established by an individual (Fisk & Schneider, 1981; Schneider & Shiffrin, 1977). Decrements in performance are expected in tasks that use control processes but not automatic processes. A person can walk and chew gum at the same time since they involve automatic processes however, a person cannot walk and operate a phone or a computer at the same time without decrement since they involve more controlled tasks. Vigilance researchers Fisk and Schneider (1981) showed that tasks that are controlled can become automatic while decreasing performance decrements. The authors increased practice and used a constantly mapped stimulus, which made participants automate the task, and they performed better than participants who were not able to develop such automatic processes. However, creating an automatic task cannot be done with every task and such training task takes a high amount of practice.

Data Limited and Resource Limited Processes

Norman and Bobrow (1975) created a similar framework to Schneider and Shiffrin (1977); however, they take more of a systems approach, labeling tasks as either resource limited or data limited. This model describes tasks by the mechanism that limits processing of the task. A data limited task is one in which performance on the task is limited by the quality or quantity of data available to complete the task. For tasks that are categorized, as data limited, no amount of cognitive resources will compensate for a lack of data to complete the task; performance is thus independent of processing (Norman & Bobrow, 1975). For example, data can be limited by the quality of the signal. In these cases, noise in the environment can lower the probability that a signal can be detected. In these situations, performance can gradually decline as the data to complete the task becomes degraded. This process affects the sensory processing stage of information processing directly by preventing a stimulus from being detected. Resource limited tasks do not depend on the data but on the amount of cognitive resources available to process the information. These tasks are similar to controlled processes in so far that tasks can interfere with each other and decreased performance is due to a lack of resources. These can typically be unlearned/practiced or novel tasks. Failures of resource-limited tasks are not gradual but catastrophic.

Failures of Attention

Attention is required for cognitive processing and decision-making and failures of attention can cause two main effects. The first being increased cognitive workload, which lowers the individual's ability to performing controlled processing tasks. The second is lowered situational awareness, which decreases an individual's ability to remain aware of their surroundings (Endsley, 1995; Wickens and Hollands, 2000). All of the prior information regarding information processing and attention is important. Not one model can explain every failure of attention however, aspects of each model can be used to describe actual human performance and account for behavior and performance completing a task under different workload conditions.

Increased cognitive workload.

Automatic tasks use little or effort and it is the controlled tasks that both utilize cognitive resources and can be impaired by a lack of cognitive resources (Fisk & Schneider, 1981; Schneider & Shiffrin, 1977). Kahneman (1973) described attention as a function of supply and demand. The overall capacity of attention is affected by both the supply and demand for cognitive resources. If the capacity exceeds the demands of the individual, then there is a space capacity that can be used for other controlled processing tasks, however, if the demand exceeds the supply then all controlled tasks suffer. Thus, failures of attention cause increased cognitive workload.

Decreased situational awareness.

Situational Awareness (SA) is an individual's ability to understand what is happening in the environment around them and which information is necessary for decision-making (Endsley, 1995). Endsley (1995) created a model of SA that contains three levels of awareness in which the next level is built upon the foundation of the preceding level. Therefore, an individual would need to obtain a formative level before they progress to a higher level. Additionally, these levels need to be obtained before a decision can be made or an action can be executed. Therefore, the theory occurs in the first or second stages (sensory input and cognitive processing) of informational processing and is highly reliant on attention and cognitive resources. SA is also affected by factors such as expectations from top down processing as well as abilities, expertise and training. It is easier to obtain higher levels of SA for tasks that have been learned to the point of automaticity. Working memory is needed to obtain higher levels of SA since new information about the environment must be combined with previous information to lead to a complete picture and future awareness. Therefore SA is limited by attentional capacity, long-term memory stores, and other cognitive resources. By obtaining full SA, one can understand the factors in the environment that are relevant for the task and are able to make better decisions based on that information. In this way is task specific therefore, the steps to obtain SA is different for different tasks such as for controlled vs. automatic tasks. Additionally, since SA is dependent on attentional factors failures of attention will decrease the likeliness that an individual can maintain a working mental model of its environment.

The Task of Driving

Since driving is a complex task, it is comprised by many subordinate tasks, which place considerable stresses on human visual, cognitive, motor, and auditory sensory abilities (Gentzler & Smither, 2012; GHSA, 2011; Groeger, 2000). Some of these tasks can be automated similar to Fisk and Schneider (1981), therefore performance on these tasks improve with practice and experience, which allows the driver to have more resources for the other driving tasks. This is one reason that inexperienced drivers, such as younger adults, have crash risks that greatly exceed older, more experienced, drivers and this crash risk declines as a function of time and driving experience (Mayhew, Simpson, & Pak, 2003). Morgan and Hancock (2009) stated that 90% of estimations, such as avoiding obstacles and navigating ones vehicle, are automatic tasks. However, other tasks are more complex and dynamic (Regan et al., 2009).

The visual tasks of driving may be one of the most important tasks since successful driving requires the driver to remain in his or her lane, maintain a safe distance from other vehicles, avoid obstacles, read and respond to traffic signs, and read his or her own vehicle's gauges to maintain speed (Groeger, 2000). The cognitive tasks of driving are also very important. Drivers' have to estimate safe distances between vehicles, time to collision, decide the best way to respond to the behavior of other vehicles and hazards. Drivers also have to decide when to refill their cars, how fast to drive, remember the rules of the road, how to operate the vehicle and other tasks (Groeger, 2000). The manual tasks of driving include the manual dexterity and physical strength of handling the controls, turing the key, shifting, steering, and accelerating the vehicle, adjusting the mirrors, seat and other settings, turning one's body (torso, neck, and head) to look around the vehicle (Groeger, 2000; Horrey & Wickens, 2006). Unlike visual and cognitive tasks, manual or motor tasks have to be done at specific times during vehicle operation, which the exception of keeping hands on the wheel to steer the vehicle and keeping ones feet on the accelerator and ready to shift to the brakes and/or clutch (GHSA, 2011; Groeger, 2000). However, this does not mean that manual tasks are unimportant. Lack of muscle strength and range of motion, which increases the difficulty of manual driving tasks are a cause of accidents of older drivers (Gentzler & Smither, 2012; Romoser & Fisher, 2009). Driving also, has a rich auditory component. Auditory tasks include hearing sirens from emergency vehicles and noticing vehicle hazards such as the wearing tires or brake pads (De Lorenzo & Eilers, 1991; Park & Choi, 2007). Tasks can also involve multiple sensory modalities depending on the complexity of the task. One such example of this is stimuli identification and orientating responses due to hazards (Groeger, 2000).

Driving and Distraction

Driving is a process that most people find simple, however individuals underestimate the many complex tasks that are required to perform driving safely (Morgan & Hancock, 2009). Therefore, performing concurrent tasks is a dangerous activity that is performed regularly. Driving is a complex visually demanding task that is prone to interference from tasks that split drivers' attentional resources such as performing secondary tasks while driving (Atchley & Dressel, 2004). Two studies have analyzed specific causes of traffic accidents. First, a studied termed "The Indiana Study" completed database, survey, and full accident investigations in the 1970's.

Secondly, Stutts, Reinfurt, Staplin, & Rodgman (2001) analyzed data based on accident reports using the national databases of crash statistics to obtain a representative sample of accidents in a given year (Wallace, 2003). Both of these studies indicated that driver distraction was a serious cause of accidents (Wallace, 2003). Later research showed that driver distraction contributes to about 25% of all crashes (NHTSA, 2010; Stutts et al., 2001). This data is further compounded by the fact that as of 2009, on average, there are 13 million vehicles on the roadways at any given time in the United States (NHTSA, 2010).

Distractions while driving can take four forms visual, manual, auditory, or cognitive (GHSA, 2011). Visual distractions shift a driver's eyes from the road. This is especially dangerous since durations of off-road glances longer than two seconds more than double one's crash risk (Klauer, Dingus, Neale, Sudweeks, & Ramsey, 2006). Manual distractions are distractions that come from a driver taking his or her hands off the wheel such as reaching for objects in the car (GHSA, 2011). Cognitive distractions come from dividing or focusing attentional resources to a task other than driving such as the distraction that comes with talking to a passenger or conversing on a wireless phone (GHSA, 2011; Strayer & Drews, 2003; Strayer & Drews, 2009).

Sources of In-Vehicle Distractions

In-vehicle, distractions occur inside the vehicle and the following are examples: Wireless phones (conversation, text messaging, using menus etc…), GPS devices, vehicle information systems, consuming edible items (food & drink), radio tuning, Ipods, passengers and others. For example, an individual using a wireless phones while driving consists of all four types of distraction. This is due to the process required to use a phone. A driver has to first pick up the phone, and then look at the screen to dial a number. Furthermore, throughout the conversation the driver has to think about the conversation. Whereas if the driver used a hands-free system, the distraction would only consist of an auditory and cognitive distraction since it removes the first two steps. However, doing so may increase cognitive distractions because this form of automation shifts the work from physical (picking up the phone) to cognitive (remembering the process to place a call based on the hand free system) (Strayer & Drews, 2003; Stutts et al., 2001; Wallace, 2003). Manual tasks of driving include using vehicle controls, and turning ones' head, torso, or neck to look around the vehicle (Groeger, 2000). Visual tasks of driving include navigating the driving environment, scanning the environment for hazards, and estimating time to collisions (GHSA, 2011). Cognitive tasks of driving include using attention to process visual and other input, from the perceptual and sensory systems, avoiding hazards, and maintaining situational awareness of the driving environment (GHSA, 2011, Groeger, 2000). The auditory tasks of driving include listening for environmental and vehicle cues that would signal a hazard (GHSA, 2011, Groeger, 2000). Together these tasks form the cohesive complex task that is simply referred to as driving. Driving is a dynamic, controlled task and when any one or more of these subtasks are interfered with it distracts the driver and interferes with a person's ability to complete the associated driving task which in turn can lead to driving errors, crashes, and other dangerous consequences (GHSA, 2011; Regan et al., 2009).

Wireless phone distractions.

Wireless phones serve as both visual and cognitive distractions and when used while driving can severely degrade driving performance (Barkana, Zadok, Morad, & Avni, 2004; Beede & Kass, 2006; Klauer et al., 2006). These phones can also at times be a manual distraction when a driver picks it up, uses the menus, or otherwise interacts with it using the tactile senses. Drivers self-report that when they use their phone while driving their chances of crashing increases (Klauer et al., 2006; NHTSA, 2010). As of 2009, on average, there are about 13 million vehicles on the road at any given time in the United States, of which approximately 672,000 of those vehicle drivers use wireless phones while driving (NHTSA, 2010). Therefore, many drivers are at risk for having fatal crashes due to driver distraction. Many of these crashes could possibly be prevented.

Phone use is one such task that forces drivers to split their attentional resources between the phone conversation and driving. The phone conversation often takes priority over the primary driving task (GHSA, 2011; NHTSA, 2010; Regan et al., 2009). When simultaneously engaging in conversation on a wireless phone and driving, people are much less likely to encode visual information (Strayer & Drews, 2007). As such, drivers are less aware of their surroundings. Because of this, drivers using phones miss traffic signals and when they detect them, they react to them more slowly. In several studies, drivers either had delayed response in braking or kept the brake pedal depressed longer than drivers who were not engaged in phone conversations (Strayer & Johnston, 2001; Strayer, Drews, & Johnston, 2003). McCarley et al. (2004) found that during a naturalistic conversation it was harder for people to detect changes in their environment.

Hand-held vs. hands free driving.

These results were also found for drivers regardless of whether the drivers used a hands free device during the conversation during conversations or held the phone manually. This occurs since the conversations themselves are a source of cognitive distraction even when the visual and manual parts of the wireless phone task are eliminated. Since the drivers actively divert attention from the task of driving and the external environment to engage in the phone task, drivers may physically see a hazard in the environment, but not have the cognitive resources to understand that it poses a danger (Strayer & Johnston, 2001; Strayer & Drews, 2007; Caird, Willness, Steel, & Scialfa, 2008).

Existing Methods to Mitigate Distraction

Several methods have been explored to minimize the distraction of in-vehicle technology on the driver. First, legislative measures have been enacted to prevent device use by automobile drivers. Approximately 40 countries have bans on handheld phone use while driving (Regan et al., 2009). In the United States, laws vary from state to state. Eight states have banned all handheld phone use and 28 states have banned hand-held cell phone use by novice drivers. As of April 2011, not a single state banned all cell phone use unequivocally (GHSA, 2011). Most laws focus on banning handheld use even though research shows that using hands free devices may be just as distracting as using a hand held phone (Barkana et al., 2004; Strayer & Johnston, 2001; Strayer & Drews, 2007; Caird et al., 2008). Since laws do not ban hands-free phone use or other dangerous distractions in cars, drivers may believe some distractions are not as dangerous as others are.

Secondly, in-vehicle technology such as automation is also being explored. Automation is any task that takes a task that a human can perform and allocates it to a machine to perform instead (Parasuraman & Mouloua, 1996). Automobile manufacturers are implementing forms of both static (fixed) and adaptive (dynamic) automation into vehicles in order to provide real-time distraction counter measures to mitigate the effects of distracted driving. Regardless of the type of automation, they have the ability to both reduce and increase workload in the driving task. Although these systems are helpful and have been proven to decrease crashes by giving driver's more time to react in a difficult situation there are some disadvantages. The systems may be pricey or restricted in their deployment. Only newer cars would receive these systems making their deployment longer-term solution. These systems may also have false alarms, which may be distracting to the driver. Parasuraman and Mouloua (1996) stated that system reliability of automated systems can mediate both workload and awareness of the environment while using the system. This indicates that false alarms can increase the workload and may increase the attentional demands on the driver (Parasuraman & Mouloua, 1996). Furthermore, these systems, in most cases, still rely on the driver to take action to avoid the collision and if the driver is sufficiently distracted, the driver may not prevent the collision. Finally, without proper training, the driver may not know how to react to the warning if one is triggered. These drivers may overreact, or not react at all. In extreme cases, the automated systems may cause the driver to lose control of the automobile (Veeramallu, 2000). Due to these issues, training may be an option to reduce distraction. The existing literature describes several programs designed to promote and improve driver's skills and performance. Regan et al., (2009) state that most of these educational programs do not incorporate training to reduce distraction while driving, therefore most drivers do not understand what distractions exist and how to reduce their effects. The authors' estimate that training programs that focused on mitigating distraction, those programs may improve driver performance (Regan et al., 2009). Research with older adults show that training programs that help improve useful field of view (UFOV) will may increase driving performance and ten one hour sessions may provide enhancements for more than one year (McKay & Maki, 2010). UFOV is a speed of processing test that requires an individual to detect objects under conditions of increasingly difficulty such as shorter display times of stimuli which can be presented on screen for as little as 17ms and as long as 500ms (McKay & Maki, 2010). Test objects are shown uniformly across the visual field including the periphery to test processing speed, and spatial attention (Roenker, Cissell, Ball, Wadley, & Edwards, 2003). Lower scores on the UFOV indicate a lower functional field of view and possibly unsafe drivers (Underwood, Phelps, Wright, Van Loon, & Galpin, 2005). Reasons for lower UFOV test scores ability to indicate unsafe drivers come from the idea that driving benefits from increased processing abilities and research performed with older drivers that showed that UFOV scores correlated with driving crashes (Ball et al., 2002).

McKay and Maki (2010) have also suggested that video games could be added to driving training programs such as the UFOV to improve training adherence since these games can be rewarding and immersive. For example, a person may be more willing to play a game rather than complete a traditional training program or in conjunction with the training program. Video games, which are used and designed for these purposes, are called serious games and have been used in a wide variety of industries (Kato, 2010). In these situations, the games are used strategically to increase the motivation of the trainee or player; this prevents boredom from preventing completion of the training program (Kato, 2010).

Other researchers, have produced results that state merely playing the action games is enough to lead to dramatic improvements in spatial abilities, divided and sustained attention, vision , reaction time, and other measures (Achtman, Green, & Bavelier, 2008; Green & Bavelier, 2003; Green & Bavelier, 2006; Dye, Green, & Bavelier, 2009a; Dye, Green, & Bavelier, 2009b; Durlach et al., 2009; Spence & Feng, 2010). For example, some research as indicated those non-gamers, who are trained to play action video games for as little as 10 hours may have improvements in visual and spatial attention abilities such as on the useful field of view tests (Green & Bavelier, 2003). These results suggest that AVGs may be extremely useful for driver training especially for those populations that already have low adherence rates such as older adults. McLaughlin, Gandy, Allaire, & Whitlock (2012) states that games can be further adapted to support this population. However, more research with AVG players is needed to determine if these results will transfer to a driving task.

Action Video Games

McGonigal (2011) stated that games are activities that share four specific traits. First, they must be goal driven with players trying to achieve a preferred outcome. Secondly, games all have a specific set of rules, which force the players to face challenges along the way to achieve the game’s goal. Thirdly, all games give players feedback on their progress, which gives players motivation to continue playing, and finally, all games require voluntary participation. When players choose to play a game, they must accept the first three traits (goal, rules, and feedback). These traits hold for all games from low fidelity board games to fully immersive games in simulated environments. Additionally, elements such as 3D graphics, a compelling story, achievements, and multiplayer modes are used to increase motivation, immersion and overall increase playtime (McGonigal, 2011). Action Video Games (AVGs) themselves are a subset of all video games. These specific games are generally thought of as extraordinarily demanding of both visual and cognitive resources, usually requiring players to attend correctly to multiple stimuli simultaneously while navigating in a three dimensional virtual environment (Achtman et al., 2008; Bavelier , 2011; Bavelier, Green, & Dye 2010; Cherney, 2008; Chisholm, 2010; Dye et al., 2009a; 2009b; Green & Bavelier, 2003; 2006; 2008; 2010). Games that are generally thought of as action games and that have been used in research are Medal of Honor, Call of Duty, Mario Kart, Unreal Tournament, World of Warcraft, and others (Dye et al., 2009a; 2009b ; Durlach, Kring, & Bowen 2009; Green & Bavelier, 2003; 2006). Mishra, Zinni, Bavelier, & Hillyard (2011) attributed AVG players' skills to having an increased SA. Researchers have also looked at both puzzle and racing games and have failed to see any differences on training interventions with these type of games (Spence & Feng, 2010). One study by Sims and Mayer (2002) trained participants for 12 hours on the puzzle game Tetris. The researchers gave participants both a pre and post measures and mental rotation. The post training scores showed that the participants only showed improvements for those shapes that closely related Tetris pieces.

Characteristics of action games.

Action games have the following attributes that separate them from other genres of video games. First, games must place heavy demands on player's visual and attentional systems. Action games often require players to maintain visual and situational awareness of their environment, which includes monitoring both central and peripheral aspects of the visual scene. Players also are required to track objects around the screen while ignoring distracting input (selective attention) (Achtman et al., 2008). Secondly, AVGs require players to achieve fast reaction times to unexpected events that are uncovered through monitoring the game environment (Achtman et al., 2008; Spence & Feng, 2010). For example, if an enemy appears on screen players are expected to immediately locate the threat and respond to it to avoid negative consequences such as failure. Thirdly, this genre requires coordinated hand eye movements in order to aim at small moving targets presented on screen during game play such as a faraway enemy (Achtman et al., 2008). Fourthly, AVGs require one to perform multiple tasks at the same time some of which compete for resources (divided attention). For example, players may have to perform a spatial navigation task, an ambient vision task where players will need to read signs, heads up displays, or other stimuli at the same time. Additionally, they have to complete a visual search task in order to scan the environment, a tracking task to acquire moving targets, and a resource management task to conserve health, ammo and other resources a game may require (Achtman et al., 2008; Wickens, 2002). Fifthly, the games must also have a large unrestricted environment for the player to explore. Large 360-degree environments allow for a larger visual environment in which to search for threats. This increases the difficulty of the visual search, navigation, and the targeting tasks of AVGs (Spence & Feng, 2010). Additionally, as long as a game encompasses these criteria, it will have similar effects to the games specifically looked at by these researchers (Green & Bavelier, 2003; 2006; 2007). Moreover, other characteristics that action games have are not only specific to their genre. Games need to be challenging and rewarding to the player. This means that games should have different difficulty levels that players need to tailor to their skill levels or the game needs adapt to the players skill in order to be challenging. It also means that games should reward players for game success. This is typically done by granting the player upgrades to equipment, better endings, or other in-game benefits (Achtman et al., 2008; Green & Bavelier, 2006; Spence & Feng 2010).

Using the characteristics of action games Mane and Donchin (1989) created a research tool similar to an AVG. Space Fortress was developed by cognitive psychologists for training and research purposes. The purpose of Space Fortress was to create a task that is representative of real tasks in order to increase its transferability outside the game (Mane & Donchin, 1989). During the task/game participants had to complete the following tasks: avoid mines and enemy weapons, navigate around the environment, attack the fortress, respond to unexpected events enemy or foes with a different response remember to use the correct weapons to destroy the fortress. Additionally, players had to identify and destroy only enemy targets, manage resources of missiles in order to succeed, constant movement of the participants' vessel, and obtain additional resources throughout the task. The task is also challenging, the researchers stated that some participants cannot complete the trials due to the task being too complex and difficult. Additionally, while it was challenging it was also rated as enjoyable by participants (some participants requested to continue playing even after 40 hours of game play) (Donchin, 1995; Mane & Donchin, 1989). This task does qualify as an action game, however, the main difference between this task and action video games created recently is the level of immersion in a 3D environment due to differences in computer power and graphics ability that is available today vs. in 1989 when the task was created (Donchin, 2005).

Evidence in support of action games

Since both video games in general and action games have been highly researched, there is a large amount of data which suggests that they are useful in driving research and in other areas to improve spatial abilities and other attentional resources (Green & Bavelier, 2003; 2006). The research can be broken down into three categories, psychometric, neurological/physiological, and real-world evidence.

Psychometric evidence.

The first involves results on different psychometric or laboratory based tests. Research in this area has found significant differences between AVG players and non-players on perceptual tests (Achtman et al., 2008; Chisholm, 2010; Green & Bavelier, 2003; Green & Bavelier, 2006; Dye et al., 2009b; Durlach et al., 2009; Spence & Feng, 2010). Green and Bavelier (2006) performed a study with 16 male participants who were either non-players or action game players. This study only used male participants due to lack of female action video game players. In this study their criteria was a minimum of 3-4 days of play a week self-reported for 6-month period prior to the study. In this study, the researchers used a visual search and target detection task (Green & Bavelier, 2006). Participants had to discriminate a square or diamond shape from a triangle or trapezoid shapes, which were all light grey in color presented on a black background. In addition, target shapes that did not appear inside of a circular shape were distracters and represented an additional discrimination participants had to make. Response times were measured by pressing a key when the target stimuli was displayed on screen and participants were given feedback and training prior to monitoring participants reaction time and percentage correct. In this experiment, the researchers suggest that video game experience correlates with faster reaction times and higher percentage of correct responses on this task (1% higher accuracy while being 37ms faster). The researchers also explain that the AVG player group continued to process the distracter stimuli dividing their attention even in the highest cognitive load condition instead of ignoring them (selective attention) indicating AVG players were better at allocating attentional resources between the tasks (Green & Bavelier, 2006).

In a separate experiment by Green and Bavelier (2006), the researchers examined effects on Useful Field of View (UFOV) on AVGs vs. non-players. In this experiment, 16 male participants were used. Each of the participants rested their chin on a chin rest 22cm from a 24in screen, which was used for the UFOV test. They reduced the stimulus size and presentation time since younger participants were expected to perform better on the test than older adults for which the test is mostly used. Green and Bavelier (2006) found that in the no distractor UFOV condition the AVG player group had significant results (higher performance). However, they did not find significance in this study in the distractor condition. This may have been caused by a lowered effect size due to participants extended task experience. The researchers did not counter balance the presence of a non-distractor and distractor condition. In addition, this experience with feedback allowed participants to have task learning which also may have lowered power (Green & Bavelier, 2006).

Another study Green and Bavelier (2007) recruited 10 AVG players and non-players based on amount of play in the last 12 months and now long they played per week. The criterion for the player group was a minimum 5 hours per week over the last 6 months and zero per week for the non-player condition. All participants were shown a letter T, which was presented on screen for 100ms and the task, was to make a perceptual judgment of whether the position of the T was right side up or flipped on the horizontal axis. The task was made more difficult by having participants judge the target stimuli while having two-distractor letter T's present on screen which could crowd the target T as well as well as varying the horizontal visual angle at either 0, 10, or 30 degrees. A follow up experimental study was conducted with both male and female non-players and were trained in an AVG however, the exact game was not specified. Green and Bavelier (2007) concluded that the results of these studies indicated an increase in the spatial resolution of vision as measured by the visual task in both experiments. This means that the AVG players and the group which was trained to play AVGs was better able to discriminate the target T as opposed to the non-player groups even when the target was crowded with multiple examples of the distractor T (Green & Bavelier (2007).

Cain, Landau, & Shimamura (2012) explored differences between an action game player group and a non-player group. The criteria for the player group was a self-rating of at least 5 out of 7 for game expertise and a minimum of 6 hours per week of self-reported play time with AVGs. The non-player group was required to have played less than 2 hours per week and rated at least a two or lower on expertise. The task used was a Flanker or an attentional task switching assessment task. This task utilized four 85-trial experimental blocks and required the participants to respond to the direction of a central arrow which was surrounded with two distractor arrows that could be congruent (same direction) or incongruent (opposite direction) (Cain et al., 2012). The researchers used longer stimulus presentation times (1300ms) to prevent possible strategy differences between players and non-players. The researchers also compared results on a lexical memory test to rule out any differences in intelligence between the groups. The data from this study indicated that AVG Players had shorter reaction times to the task-switching task (Cain et al., 2012).

Physiological evidence.

The second type of evidence for performance differences come from neurological studies of either brain scans or measuring differences in neurotransmitter levels between gamers and non-gamers. Schwenkreis, et al. (2007) found more activation in the somatasensory cortex in expert violin players as compared to non-players. Past research in this area has dubbed the effect Training-Induced Cortical Plasticity, meaning that training can lead to more area devoted to that area in the cortex related to the area of practice. Research with video game players has also been conducted on this phenomenon. Saito, Mukawa, & Saito (2008) tracked brain activation to video games in general not specifically AVGs and utilized Othello (strategy board game), Tetris (Puzzle Game), and Space Invaders during play using fMRI. The results of the study showed that the brain activation was positively related to the skills required to play the games. Participants who played Tetris or Space Invaders, which required fast reaction times, showed activation in broad areas of the pre-motor cortex. The results also showed that participants who played Othello, which required strategic skills, showed more activation in the pre-frontal cortex. However, all of the games achieved some activation in both right and left pre-frontal and pre-motor cortices as well as bilateral activation in the visual association cortex (Saito, et al. 2008). In addition, other brain research has found that the more often neural pathways are used, the stronger the connections will be between them and the more likely they will be used again (Goldstein, 2010; Morris, 1999).

Players of AVGs may have to make use of not only strategic skills and react quickly, but complete more complex actions than the three test games in the Saito, et al.2008 study (Spence & Feng, 2010). It follows that action game players would gain similar benefits to the overall video game findings and may increase them since AVGs are more demanding. The requirements of the AVGs may also dictate which pathways that are strengthened over time such as the Training-Induced Cortical Plasticity effect seen in violin players.

Research by Koepp, et al. (1998) shows that increased extracellular neurotransmission of dopamine in the ventral and dorsal striata of the brain may indicate an increased level of reward. In this study, participants were given PET-scans either while they played an action video game involving controlling a tank to destroy enemies and collect flags or while staring at a blank screen. The results showed an increased level of extracellular dopamine even after 30 minutes after the game ended as compared with the baseline scan. The levels of dopamine in the brain in the video game condition were similar to primate studies with injected amphetamine and methylphenidate. The results also showed a significant positive correlation with game performance and increased dopamine levels in the ventral striata. The release of dopamine has been indicated to increase the salience of objects in ones’ environment and increase reward and motivation (Berridge & Robinson, 1998; Kapur, 2003). Additional studies show that dopamine release plays a critical part in reward-based learning. Furthermore, researchers have shown increased activation of dopaminergic pathways and neurotransmitter synthesis during reward-based learning (Beninger & Miller, 1998). This indicates that the release of dopamine from playing video games may assist in the acquisition of skills from video games. However, the games used for this research are not specifically action games therefore, these effects may be present in all video games and it may just increase players' motivation and increase skill at playing the games.

Maclin, et al. (2011) studied how the brain changed through practice and play with the Space Fortress game. In this study, 37 participants, with low video game experience and those who reported playing less than 3 hours a week for the last 2 years were given 20 hours of practice on Space Fortress. Over the course of training participants improved game and secondary task performance. The authors indicated that attentional resources were freed through automating some of the games sub tasks or development of increased attentional resource capacity (Maclin et al., 2011).

Li et al. (2009) studied the effect of AVG training on contrast sensitivity function (CSF). CSF is the minimum amount of contrast that is required to resolve a specific sine wave grating as a function of spatial frequency (Applegate and Massof, 1975). These researchers took non-players, trained them for 50 hours over 9 weeks on Unreal Tournament 2004 and Call of Duty 2, and compared them to a control group who played a non-AVG (Li, Polat, Makous, & Bavelier, 2009). The experimental group improved significantly over the control group at the CSF task used based on a pretest-posttest study design (Caplovitz & Kastner, 2009).

Real world evidence for action games.

The final type of evidence has been the hardest to see in research studies. Real world evidence would be the situations in which the video game skills transfer to another realistic task such as driving. Real world studies are harder to complete than a psychometric evaluation of skills, however they are necessary to validate whether the skill improvements that have been shown on laboratory tests transfer to the real world (Durlach et al., 2009). Schuster, Fincannon, Jentsch, Keebler, & Evans (2008) stated that higher video game experience is linked to increased route planning and execution skills, which rely heavily on spatial orientation and visualization skills. These skills are useful for operators of unmanned vehicles. This skill is thought to transfer since both in video games and in unmanned vehicle operation the viewpoint of the individual is quite different than it is during normal vision and it is required to accurately play certain games. The researchers took 120 participants, gave them a video game questionnaire, and had participants perform unmanned vehicle route planning and execution tasks. The researchers found significant correlations between video game experience and spatial ability scores, both psychometrically and as shown through the unmanned vehicle task (Schuster et al., 2008). Cherney (2008) also found similar results using mental rotation questionnaires.

Next, Rosenberg et al. (2005) identified that video game experience as correlated with increased visuomotor skills in novice surgeons. An additional, correlational study was performed in which 33 medical residents and attending physicians who were participating in a laparoscopic training program were also assessed for video game experience and participants with more than 3 hours per week video game experience performed 24% faster and had a 26% better overall score on the laparoscopic training program (Rosser, et al. (2007). Additionally, Fery and Ponserre (2001) matched 62 right-handed male non-golf playing participants for mental imagery ability and assigned participants to an experimental or control condition to learn golf skills. All participants were pre and post tested on a putting green. The study showed that those who were trained in the video game showed significant improvement from pre to post test in putting skill.

Possible Self Selection Bias of Video Action gamers

Some methodological issues exist between studies that compare non-action gamers and expert action gamers. For example, individuals who do not play AVGs may refuse to do so because they lack the capacity for the spatial, visual, and attentional skills that are required action games and thus study results may represent differences in skill capacities instead of video game play (Spence & Feng, 2010). Boot, Blakely, & Simons (2011) also suggests other factors may exist between self-selection of gamers and attentional abilities. Erikson, et al. (2010) explored one such self-selection bias. The researchers wanted to look at reasons why both confirmatory and discouraging results exist in the field of video game skill transfer and the researchers investigated whether the performance differences of the Space Fortress game could be established based on a neuroanatomical analysis instead of amounts of game play. In a sample, size of 42 non video game player participants the researchers discovered that the volume specific brain areas can predict performance, such as the striatum. The researchers stated that this brain area is related to cognitive flexibility and procedural learning (Erikson et al., 2010). These results suggest that certain neurological differences, such as the striatal volume may cause some people to do better than another on AVGs and on other complex tasks and not the direct result of game play.

Evidence Against Action Games

Although, as stated earlier, many studies have found significant differences using AVGs, many other studies have found no differences or low effect sizes when comparing AVG players with non-players, however, these studies are seen much more rarely since non-statistically significant research often is not published. Rosenthal (1979) called this problem the "file drawer problem" and suggests that only small subsets of all articles on a subject are actually published. Therefore, the research community may be receiving a biased argument by only seeing significant studies.

Psychometric evidence against action games.

Murphy and Spencer (2009) tried to replicate the findings of Green and Bavelier (2003)'s study. The researchers tested 75 male participants between the age of 17 and 25 years. Those in the AVG group had higher scores on several tasks including an attentional blink task, a UFOV task, and an intentional blindness task. Unlike the findings of Green and Bavelier, which showed significant differences between groups, Murphy and Spencer, did not have the same findings. AVG players only performed better on the shortest intervals of the attentional blink task and they failed to find significant effects on the other intervals, which may not be a realistic difference.

Boot, et al. (2010) investigated whether strategy differences in Space Fortress game play would affect skill transfer to other tasks. Forty-two participants' who reported playing less than 3 hours of video game experience per week in the last two years were recruited. The researchers had participants use one of two different strategies, in the first strategy the entire task was emphasized whereas the other strategy utilized different blocks of trials, which were designed to emphasize different aspects of the game. The latter group mastered the game quicker and had a higher performance rate than the former strategy. Both groups were given 20 hours of training on Space Fortress and then tested on several cognitive tests (attentional task switching, attentional blink, Sternberg memory test, N-Back, Flanker, dual task manual tracking, and others) along with a flight simulator and radar-monitoring task. Participants' only showed skill transfer in the second strategy and only to those tasks similar to the Space Fortress game such as manual control and memory tasks. The researchers expected to see increases in the Flanker, task switching, N-back, and attentional blink tests if the Space Fortress training improved attentional capacity or allocation, which were not seen in the data set (Boot et al., 2010).

Another study Stern, et al. (2011) also tested the Space Fortress game by giving 60 cognitively healthy older adults 36 one hour training sessions over three months with pre, during and post cognitive testing (WAIS-III cognitive subtests, trail making test, Stroop, California Verbal Learning test, Flanker task, attentional set-switching task and others). The researchers found only limited support that the Space Fortress game play transferred skill to the cognitive measures given and did not show that the changes were sustained three months after cessation of the experiment. The researchers also suggested that the older adults spent more time trying to adapt to the frictionless control of the space ship in the game which could have minimized some skill gain and transfer with was supported by other researchers (Blumen, Gopher, Steinerman, & Stern 2010; Stern et al., 2011).

Physiological evidence against action games.

Bailey, West, and Anderson (2010) recruited 51 male participants between the ages of 18-33 years who were divided into groups of high and low play based on a screening survey. Participants were then given a Stroop color word test while their performance data was analyzed using a neurological analysis. The researchers discovered that their measures of cognitive control were affected by game experience, however, higher AVG experienced participants were unable to maintain proactive cognitive control, and the researchers' data does not support the hypothesis that the higher AVG experience is positively related to the ability to overcome interference with distracters.

Real world evidence against action games.

Although there has been a lot of psychometric and physiological research on video games, there is little research in the literature that has examined differences on real world tasks and some of the research that has been conducted failed to find significant effects (Durlach et al., 2009). With a lack of findings, more research is needed to determine if the performance differences shown in lab tests really do transfer to real world tasks. In some experimental results, AVG benefits were only seen in extreme cases or difficulties; therefore, differences may disappear at lower difficulty levels often seen in real world tasks whereas the controlled conditions of the laboratory allow for the levels of difficulty needed to show differences (Green & Bavelier, 2006). Durlach et al., (2009) trained participants for 10 days on either an AVG or a non-AVG game. The researchers were unable to find any significant differences between AVG players and non-players during a military monitoring task for change detection although they were able to on psychometric tests of change detection. Therefore, the skills did not transfer to the real life task. However, gender differences between groups may have accounted for that finding since there were an unequal number of males and female participants. Jäncke and Klimmt (2011) found that although in computerized tests of attention those with higher video game experience scored significantly higher, this skill did not transfer to a driving simulator and as such may create a performance bias on computerized tests, without actually improving driving skills.

Issues with Previous Action Game Studies

Boot, et al. (2011) suggests that if gamers are informed that they were recruited based on expertise with AVGs it may influence them to perform better than the non-experts. The demand characteristics of the task may motivate expert gamers to perform better than the non-experts. The authors recommend using a covert recruitment including prescreening well in advance of the study or screening after for AVG experience. Secondly, Boot, et al. (2011) suggests the training studies such as Green and Bavelier (2003; 2006) and Li et al., (2009) may also be flawed since participants know that the gaming may make a difference and thus a placebo or illusory correlation effect may occur. Ozdamli, Bicen, & Demirok (2011) surveyed 4,823 high school students and found that they commonly thought that video games improved both visuomotor skills, and spatial abilities.

Additionally, Boot, et al. (2011) found that fast-paced games may cause better performance on similarly fast-paced tasks, and puzzle games may cause increases on mental rotation tests, similar to a placebo effect, based on the fact the participants might think that the games may improve skills. Therefore, the control conditions used in AVG studies of Tetris may also cause placebo effects. Covert techniques or asking participants a debriefing questionnaire about the task may be needed to control for these effects.

Current Study

In light of these contradictory findings of both support and lack thereof for the effects of action video game experience on both laboratory tests and skill transfer to real world tasks and the criticisms of research findings, there is a need to replicate and expand on current research findings using an improved methodological approach. The current study looks at the effects of AVG experience in a correlational research design. The study utilized deception in participant recruitment by masking the video game experience questionnaire as an extension of the motion history questionnaire used in the study. Participants were told that experiences with certain games were related to motion and simulator sickness, and therefore their recent playing history was necessary to understand their risk for simulator sickness. Participants were only told of the truth during debriefing. This was to overcome research criticism from Boot, Kramer, Simons, Fabiani, & Gratton (2008) and Boot et al. (2011).

Hypotheses.

The main hypothesis studied in this experiment is whether AVG experience improves resistance to phone-induced distractions while driving. It is also expected that the phone conversation will cause higher reported workload and a higher number of lane deviations in all participants. If the skills gained by playing AVGs then participants with higher, AVG experience will show weaker effects of distraction than those with no or low AVG experience. In other words, there will be an interaction between AVG experience and distraction. In addition, higher AVG experience should also have a lower score on the CFQ since it measures failures of attention. These findings would be consistent with the hypothesis that AVG players can allocate attentional resources more efficiently than non-players can.   It is further expected that those with higher AVG experience will also perform better on the spatial ability measures since they are similar to the psychometric tests completed by previous researchers.

CHAPTER THREE: METHODOLOGY

Participants

Table 1: Descriptive statistics of participants

Participants	*Number*	*M*	*SD*
N	44		
Age (years)	18-32	20.22	3.16
Driving Experience (Years)	1-15	4.16	3.00
Miles per Year	600-20,000	16,762	3,096
Number of Accidents over the last year	0-1	0.136	0.345
Wireless Phone Use (years)	3-17	7	2.58
Wireless Phone Owners (%)	100		
Phone Use while Driving (%)	77.8		
Confidence During Phone use and driving (%)	74		
Video Game Experience -Last 6 Months (Hours)	0-70	11.04	13.78
Action Game Experience- Last 6 Months (Hours)	0-70	5.84	11.36
Action Game Preference (%)	92		

All participants were recruited at a southeastern university and had the option to receive course credit for participating in the study. Participants completed an online screening survey prior to coming into the lab. They were only selected to participate in the lab portion if they rated as a low risk for simulator sickness as defined by a SSQ score of lower than two moderate responses, or one severe response, had a valid driver’s license, and reported no impairments to vision, sensory, or perceptual systems. The participants were also screened upon arriving at the lab and were only allowed to participate if they had normal or corrected to normal visual acuity (better than 20/40), color vision (passed color vision testing), and contrast sensitivity. Fifty male participants participated in both the online and in lab portion of the experiment. Five participants did not finish the in lab portion either due to technical difficulties with the simulator or due to withdrawing for simulator sickness, and 1 participants was removed from the analysis for being outside of 3 standard deviations for game experience, which left 44 participants for data analysis. The participants' ages ranged from 18-32 years with a mean age of 20.22 years and a standard deviation of 3.16 years. Participants' driving experience ranged from 1-15 years, with a mean of 4.16 years of driving experience and a mean of 16,762 miles driven per year. Furthermore, all participants stated they had no more than one accident and no more than two tickets within the last year. Participants' wireless phone use ranged between 3-17 years with a mean use of 7 years and a standard deviation of 2.58 years. Additionally, 77.8% of participants' self-reported that they talk on the phone regularly while driving and 100% reported owning a mobile phone. Moreover, 74% of participants reported being confident in their skills of talking on the phone while driving.

Overall video game experience ranged from 0-70 hours of play per week within the last 6 months with a mean experience of 11.04 hours per week and standard deviation of 13.78 hours per week. AVG experience had a mean experience of 5.84 hours per week and a standard deviation of 11.36 hours per week over the last 6 months. Finally, 92% of participants rated their preference for action video games as at least a 4 on a 1-7 scale with 1 listed as strongly avoid and 7 as strongly prefer. None of the participants' reported knowing the true nature of the experiment and all listed that the experiment was testing participants' ability to drive and converse on a wireless phone.

Design

Due to the differences in spatial abilities between the sexes, only males were recruited for this study (Spence & Feng, 2010). The study was a mixed repeated measures design, which compared the amount of Action Video Game (AVG) experience (between subjects) on the presence of a distracter phone condition (Within subjects). The participants were asked to drive through a simulated environment while obeying all traffic rules. During the drive, lane deviations were recorded and analyzed. Lane deviations were defined as anytime a participant crossed the lane dividers without signaling or without reason. Lane deviations were rated from video recordings of the participants' drive by two raters who were trained In order to have an inter-rater reliability of over 90%. Subjective measures of performance included participants' self-reported workload (NASA-TLX) (Hart & Staveland, 1988). During the distraction condition, the participants were asked questions of varying difficulty. Question difficulty was based on how much cognitive resources the participant must use to answer them as self-reported by participants in a pilot study before the current study was run. This was done to ensure that all of the participants get questions with a similar level of difficulty and that they achieved at-least a moderate difficulty rating. The pilot study was conducted as an online questionnaire given at a southeastern university. A master list of 50 questions were given to 60 undergraduate students and rated on a seven point Likert type scale. Questions used in the study were restricted to those, which scored at least a four on the rating scale. The target questions were all are open-ended questions that might be asked in an introductory conversation.

Materials

The screening tools in this study included several questionnaires. The Driving Habits Questionnaire (DHQ), Motion History Questionnaire (MHQ), Simulator Sickness Questionnaire (SSQ), Demographic Questionnaire (DQ), Phone Habits Questionnaire (PHQ), Video Game Experience Questionnaire (VGQ), Adult ADHD Response Survey (ASRS) developed by Adler, Kessler, & Spencer (2003) and a battery of vision tests given on an Optec vision screener (Snellen far acuity, contrast sensitivity, and Ishihara color blindness test). Both the MHQ and the SSQ surveys were developed by Kennedy and associates as a measure to reduce the risk of simulator sickness (Kennedy, Fowlkes, Berbaum, & Lilienthal, 1992; Kennedy, Lane, Berbaum, & Lilienthal, 1993). The DHQ used in this study was developed by Owsley, Stalvey, Wells, & Sloane (1999) and will be modified for use in this study. NASA developed the NASA-TLX as a subjective questionnaire of workload (Hart, 2006).

A GE I-SIM PatrolSim Mark-II+ high fidelity driving simulator was used in this study. The simulator has three projector screens. One screen is directly in front of the participant and two screens are on either side to create a 180-degree field view at a resolution of 1280x1024 pixels. Driving scenarios are presented on the three screens using three separate projectors (one for each screen). These screens all have the same dimensions (122cm Height x 107cm Length). The driver's seat is on a variable length track that the drivers can adjust for comfort. Due to the variability of seat position, the participants are located 140-160cm away from the projector screens. The vertical visual angles measure 44.58° (main screen) and 48.93° (side screens). The horizontal visual angles measure 39.25° (main screen) and 43.53° (side screens). The overall horizontal visual angle of all three screens is approximately 126.32°.

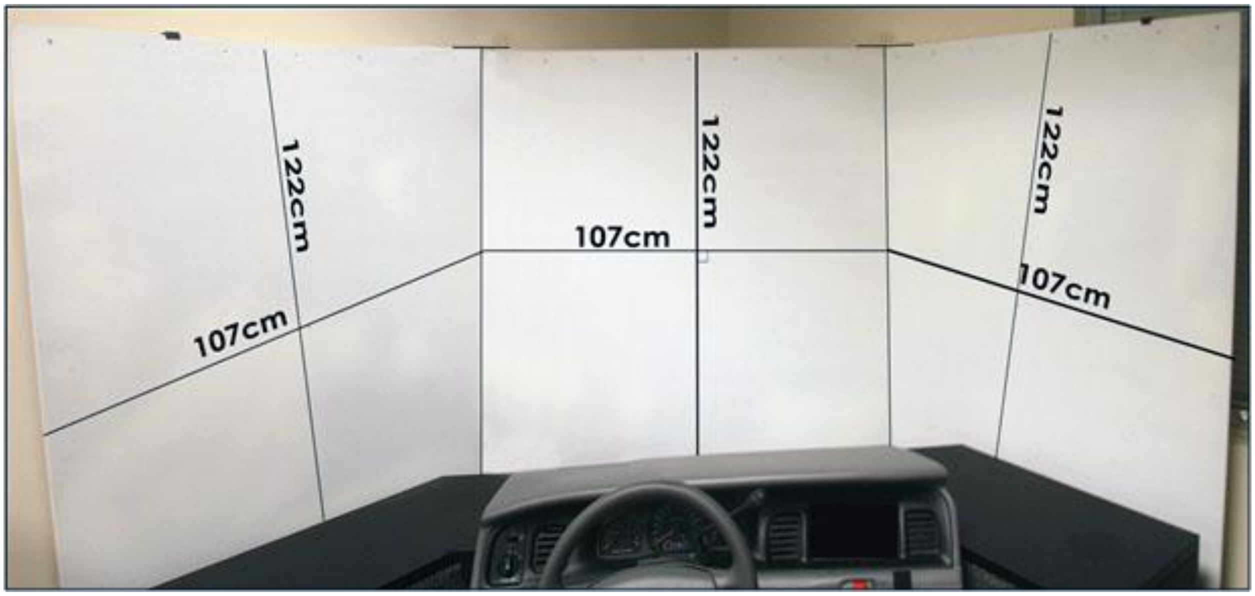

Figure 1: The ISIM driving simulator with screen size shown

Figure 2: A close up of the ISIM steering wheel

This simulator is a replica of a 1990's style automatic transmission Ford Crown Victoria including the instruments, dashboard, steering wheel, driver's seat, and pedals. The driving simulator used in this study has been found to be both reliable and valid as a substitute for in-vivo studies of driving. Situations from police crash reports were recreated in the simulator environment and these results positively correlated with the accident data. Thus, the simulator was shown to be both reliable and valid in representing a realistic driving environment (Dos Santos, 2007).

Figure 3 Example of a participant driving in the simulator

Questionnaires.

Given in Online Prescreen

- **DHQ (Driving Habits Questionnaire)**
    - This questionnaire asked participants to list their driving habits and experience.
- **CFQ (Cognitive Failures Questionnaire)**
    - Describes lapses in every day attention and higher attentional failures are related to driving errors (Broadbent, Cooper, FitzGerald, & Parkes, 1982).
- **MHQ (Motion History Questionnaire)**
    - Participants listed their experience in situations that are known for causing motion sickness in this questionnaire. This questionnaire has been tested as valid for estimating a participant's susceptibility to motion and or simulator sickness (Kennedy et al., 1992). This was given online to rule out risk for sickness. Participants who rate a high risk for sickness were not chosen to participate in this study.
- **DQ (Demographic Questionnaire)**
    - Participants list demographic information in this questionnaire.
- **PHQ (Phone-Habits Questionnaire)**

    - Participants list their experience using various mobile phone types and their demographic information in this questionnaire. This will be completed during the prescreening online.

- **VGQ (Video Game Experience Questionnaire)**
    - Participants list their experience with various video games in this questionnaire. This will be completed during the prescreening online.
    - Participants were told that this questionnaire was an extension of the motion history questionnaire and that video game experience was related to likeliness of becoming sick in the simulator. This questionnaire was portrayed this way to ensure that the participants' would not know the true nature of the experiment prior to participation. Boot et al. (2011) noted that many prior AVG studies may have artificially inflated results by not hiding this fact from participants.

- **ASRS-1.1 (Adult Symptom Response Survey)**
    - This is used to screen out ADHD participants (Adler, Kessler, & Spencer, 2003).
    - Simulated environments have been used as treatments for ADHD, individuals who have been diagnosed with the condition may be more likely to play video games, and this population typically has lower driving performance (Michaelis, 2011).

Given in Lab Session

- **SSQ (Simulator Sickness Questionnaire)**
    - The SSQ is a checklist of 31 symptoms that are subjectively rated on a four point Likert-type scale. High ratings on this questionnaire have been correlated with increased risk of Motion and/or Simulator sickness (Kennedy et al, 1991). This is given immediately before exposure in the simulator (Kennedy, et al., 1993).

- **Optec Vision Screener Questionnaire**
    - The researcher filled out this questionnaire during the vision screening. It had spaces for Snellen far acuity, Ishihara color blindness test, and contrast sensitivity functions.

- **PFT (Paper Folding Test)**
    - This task showed the participants a folded piece of paper with a hole punched into it and the participants had a list of five choices that represent the unfolded piece of paper and they are asked to select the correct one (Carroll, 1993).

- **SO (Spatial Orientation Test)**

  - This test loads on SO and required participants to determine if a reference figure is the same or different from a target figure when it is rotated (Fincanon, Evans, Jentsch, & Keebler, 2008).

- **NASA-TLX**
  - This is the NASA Task Load Index. This questionnaire was developed by NASA to evaluate subjective workloads (Hart & Staveland, 1988).

- **Recall (Conversation)**
  - This questionnaire was used to ensure that participants' paid attention to the questions during the second drive of the study. Participants listed the questions that they remembered from the distraction drive.

Figure 4: Optec vision screener

Spatial abilities.

Morgan and Hancock (2009) explained that during a typical drive the average driver has to navigate around the environment while avoiding children, other pedestrians, and obstacles that may be in the driver's path, which requires many feats of estimation, precision control, and quickly shifting attention to important events. Having higher spatial abilities makes the process of making those complex estimations much easier (Leibowitz & Post, 1982; Morgan & Hancock, 2009). Two types of spatial skills especially helpful for these tasks are Spatial Orientation (SO) and Visualization (SV). Both skills require the use of short-term visual memory. SO is our ability to perceive patterns, define and maintain our own orientation relative to the space around us (Ekstrom, French, Harman, & Dermen, 1976). This skill also helps us from being disorientated by changing orientations of spatial information. This skill does not solely require mentally rotating objects, only our perspective of the environment relative to the object (McGee, 1979). This skill is helpful for tasks that require a sense of direction such as finding one's way around a city and reading maps (or GPS). SV is ones' ability to mentally manipulate both 2-D and 3-D objects (Ekstrom et al., 1976; Kaufman, 2007; McGee, 1979). An individual can use these skills to control the vehicle, interact with the numerous other devices that we use every day while driving as well as locate, and discern the meaningfulness of the objects present in the visual scene around the vehicle (Kaufman, 2007; Leibowitz & Post, 1982; Morgan & Hancock, 2009). This includes avoiding pedestrians, cars running red lights, and emergencies that may arise during driving.

Nasa-tlx.

The NASA Task Load Index (Hart, 2006) has been used to measure subjective workload since it was developed over 20 years ago. In a survey of 550 studies that have used this index, the scale was found to be reliable, impart low demand on the participant to complete, and sensitive to measuring workload (Hart, 2006; Jerome, Ganey, Mouloua, & Hancock, 2002). The questionnaire is a muti-dimensional rating scale based on six subscales (Mental Workload, Physical Workload, Temporal Workload, Subjective rating of performance, Effort and Frustration) that is rated from 0 to 100 (Hart, 2006). This questionnaire asked the participant to rate several different factors that relate to their performance and is quick to administer (Hart, 2006).

Cognitive failures questionnaire.

The Cognitive Failures Questionnaire (CFQ) was developed by Broadbent et al. (1982) is a 25-item questionnaire that accesses the attentional failures in the areas of perception, memory, and motor function (Broadbent et al., 1982; Wallace, 2003). Cognitive failures were defined as a mistake or failure to perform an action that should be within the normal capabilities of the individual, or failures to maintain attentional capacity (Wallace and Vodanovich, 2003). Wallace et al. (2002) completed a factor analysis from a total sample of 335 participants who completed the CFQ. These researchers identified that the questions loaded on four factors, which were Memory, Distractibility, Blunders, and Names. The memory subscale consisted of eight items on the questionnaire related to memory errors (Items: 3, 6, 12, 13, 16, 17, 18, & 23). The distractibility subscale consisted of nine items (Items: 1, 2, 3, 4, 15, 19, 21, 22, & 25) which related to disturbances of attention. The blunders subscale consisted of seven items (Items: 5, 8, 9, 10, 11, 14, & 24) and related to poor motor control and social slips (Wallace et al., 2002). The final subscale names had only two questions (7 & 20) and were related to failures to remember names. This four-factor solution for the CFQ has been rated as the best factor structure examined for the cognitive failures predicted by the CFQ (Wallace, 2004). Larson and Merritt (1991) showed that higher scores on the CFQ (more cognitive failures) positively correlated with self-reports of at fault automobile crashes. This indicates that drivers who commit more errors of attention may cause more crashes than those who do not commit as many failures. Furthermore, the blunders factor predicted the most variance when the questionnaire was used to predict automobile crashes, which was significant when predicting work related accidents (Wallace & Vodanovich, 2003). These two studies indicate that this measure may hold value as a predictor of crash risk.

Procedure

Participants first completed several prescreening questionnaires online before participation in the study. The online informed consent, DHQ, PHQ, MHQ, CFQ, DQ, ASRS, and VGQ were completed in the screening. This process was completed online 3-5 days prior to arrival for their session and participants were emailed to sign up for a timeslot. Upon arriving in the lab, every participant was given an informed consent document; next, participants were given the vision screening. After the vision screening all participants were given six minutes to complete the PFT (3 minutes each part) as well as another six minutes to complete the Spatial Orientation test. These tests were counter balanced and summed to create a total spatial ability score. Participants' received a .25-point deduction of their score for any wrong answers and were told to be accurate as possible while completing the questionnaires. The NASA-TLX was given as a base line after vision tests and again after the spatial ability questionnaires in order to give the participants additional experience completing the measure. Before heading into the simulator, the participants were given the SSQ. This timing of the SSQ is used to ensure that the participants' risk of sickness is assessed immediately before being exposed to the simulator.

After completing the SSQ successfully, the participants were led into the simulator room. Once there, participants were asked to sit in the driving seat of the simulator and adjust the seat so they are comfortable. All participants drove a 10-minute practice city drive to get used to the simulator. Next, the participants received the non-distraction condition first followed by the distraction condition, and finally an additional non-distraction condition. All three drives after the practice were in a highway scenario. Participants drove drives in total and all were 10 minutes in length. Participants were given a two-minute break between drives. The NASA-TLX and recall questionnaires will be given immediately following all conditions and the SSQ will be administered after each condition including the practice drive. This is done to reduce the risk of sickness on the remaining drives.

The non-distracted drives consisted of the participant driving for 10 minutes around the simulated driving environment in a highway scenario with light traffic. The distraction condition required participants to complete a simulated hands-free wireless phone conversation along the drive. Questions were prerecorded, randomized, and asked throughout the drive. At the conclusion of the drive, the participants were given a final SSQ and then the participant all were asked if they knew the true nature of the experiment and then giving a debriefing form prior to leaving. Participants who did not return to their baseline rating for the SSQ were be asked to stay an additional five minutes and retested until they were back to their baseline rating.

CHAPTER FOUR: RESULTS

The video game experience measures were positively skewed therefore a log transformation was applied to the data in SPSS prior to analysis. The transformation was applied in order to normalize the data.

Research Question 1

It was hypothesized that the level of AVG experience would be positively related to the spatial ability and the CFQ scores. The action video game experience scores were positively correlated to the spatial ability scores, r (42) = .389 p < .01, R^2 =.152, supporting the hypothesis. Furthermore, the amount of action game play was not related to the scores on the CFQ.

Table 2: The effects of AVG experience on the CFQ

Variable	*B*	*SE B*	*ß*	*t*
Cognitive Failures Total Score				
Memory Subscale	-0.42	0.321	-0.364	-1.307
Distractibility Subscale	0.412	0.363	0.348	1.136
Blunders Subscale	0.24	0.359	0.146	0.669
Name Subscale	-0.6	0.5	-0.223	-1.201

** P < .05; ** P <.001*

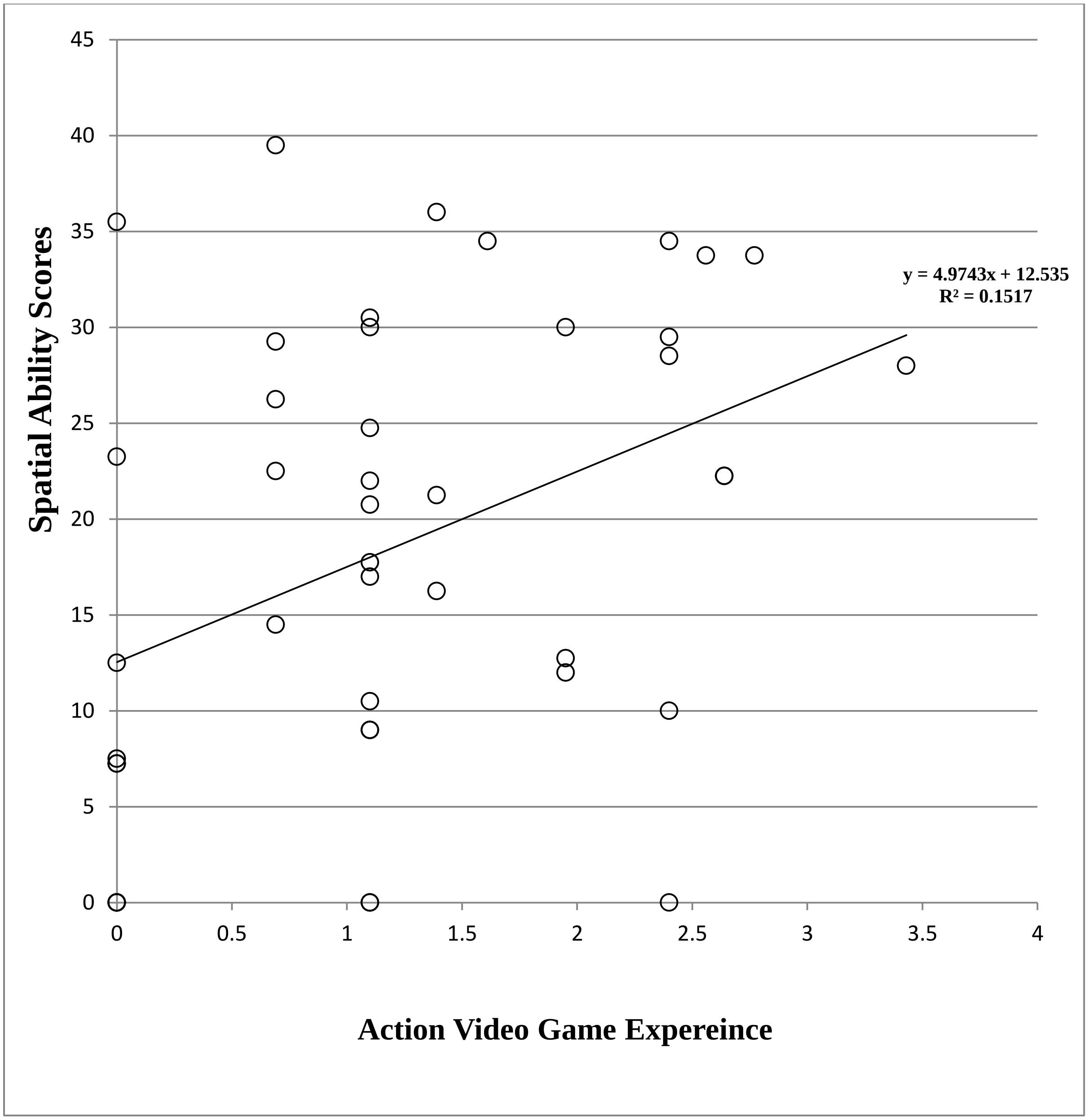

Figure 5: Correlation between spatial ability scores & AVG experience

Research Question 2

Participants remembered a mean of five questions on the conversation recall task, indicating that they paid attention to the questions during the drive. A repeated measure one way ANOVA was used to determine if the participants had a higher level of self-reported workload during the distraction condition as reported on the NASA-TLX. The effect of distraction on workload was significant, F (2.17, 93.36) = 22.55, $p<.001$, $R^2 =.34$. Post hoc tests were completed using repeated measures dependent T tests utilizing a Bonferroni alpha adjustment. The results showed that the second drive workload score (distraction condition) (*M* = 53.15, *SD* = 17.48) was significantly higher than the baseline workload score (*M* = 36.35, *SD* = 17.38), the first drive score (*M* = 30.04, *SD* = 14.68), and the third drive workload score (*M* = 40.33, *SD* = 15.84). There were no differences in workload between the baseline drive, the first drive, and the third drive.

An additional, repeated measure one way ANOVA was conducted in order to determine if the participants in the distraction condition had more lane deviations than in the control drives. Post hoc tests were completed using repeated measures dependent T tests utilizing a Bonferroni alpha adjustment. The results showed that the first drive (*M* = 2.2, *SD* = 2.76) had significantly less lane deviations than the second drive (*M* = 3.66, *SD* = 4.60), but not the third drive (*M* = 2.4, *SD* = 2.96).

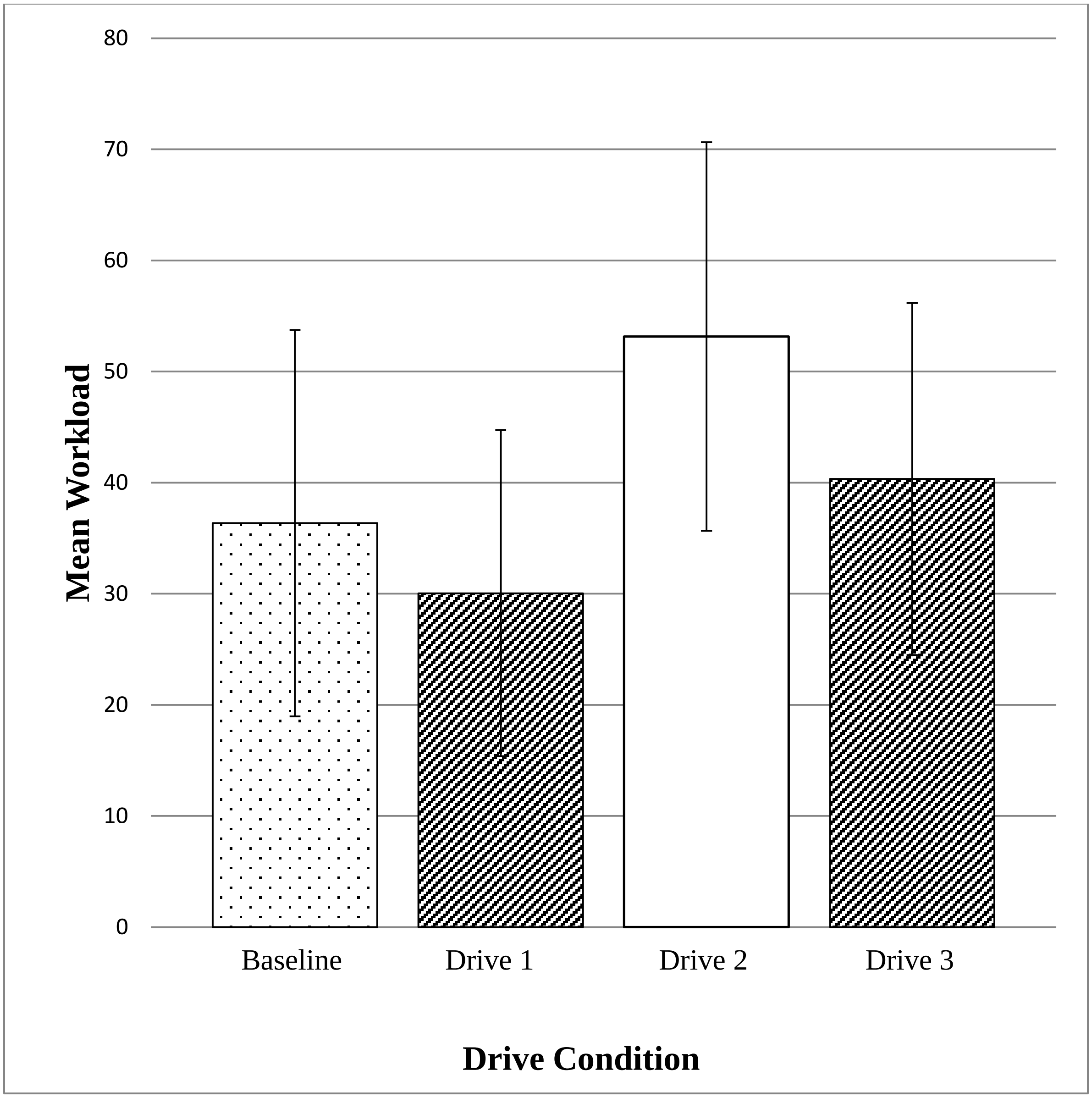

Figure 6: Mean workload per drive

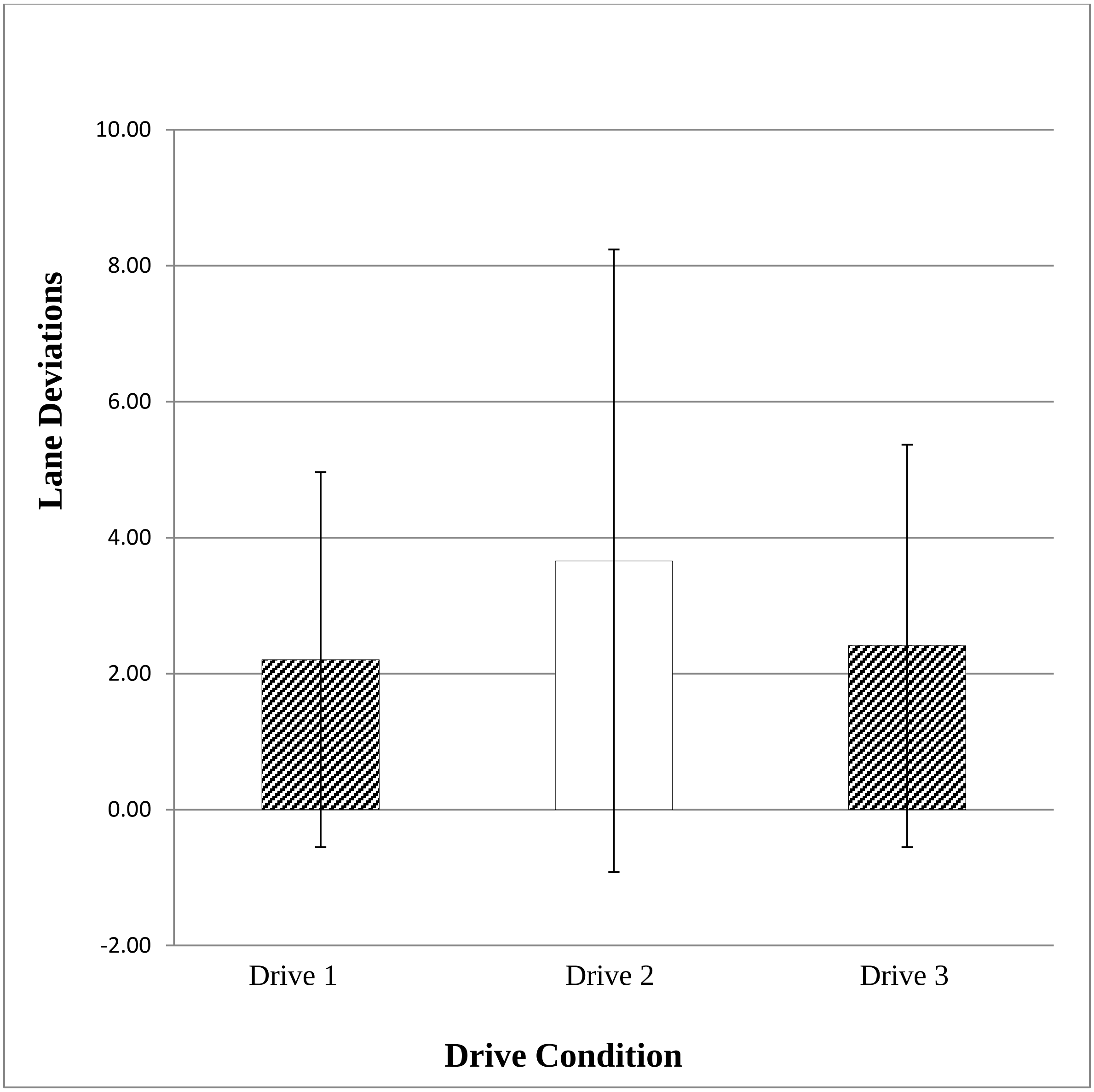

Figure 7: Mean lane deviations per drive

Research Question 3

A hierarchical linear regression was used to determine if higher amounts of video game play per week is related to fewer lane deviations in the distraction condition. The regression model was significant; the main effect of amount of action game experience per week was negatively related to the amount of lane deviations, b = -2.58, T (43) =-2.841, $p < .05$, R^2 =.116 for action game experience. However, the interaction of action game experience and driving conditions was not significant. Additionally, the effect of action game play per week on the total amount of workload experienced in the study was also not significant.

Table 3: The effects of action game experience on lane deviations

Variable	*B*	*SE B*	*ß*	*t*	R^2
Action Video Game Experience	-2.58	0.908	-0.289	-2.841*	0.116
Interaction	-1.006	1.824	-0.098	-0.551	

** P < .05; ** P <.001*

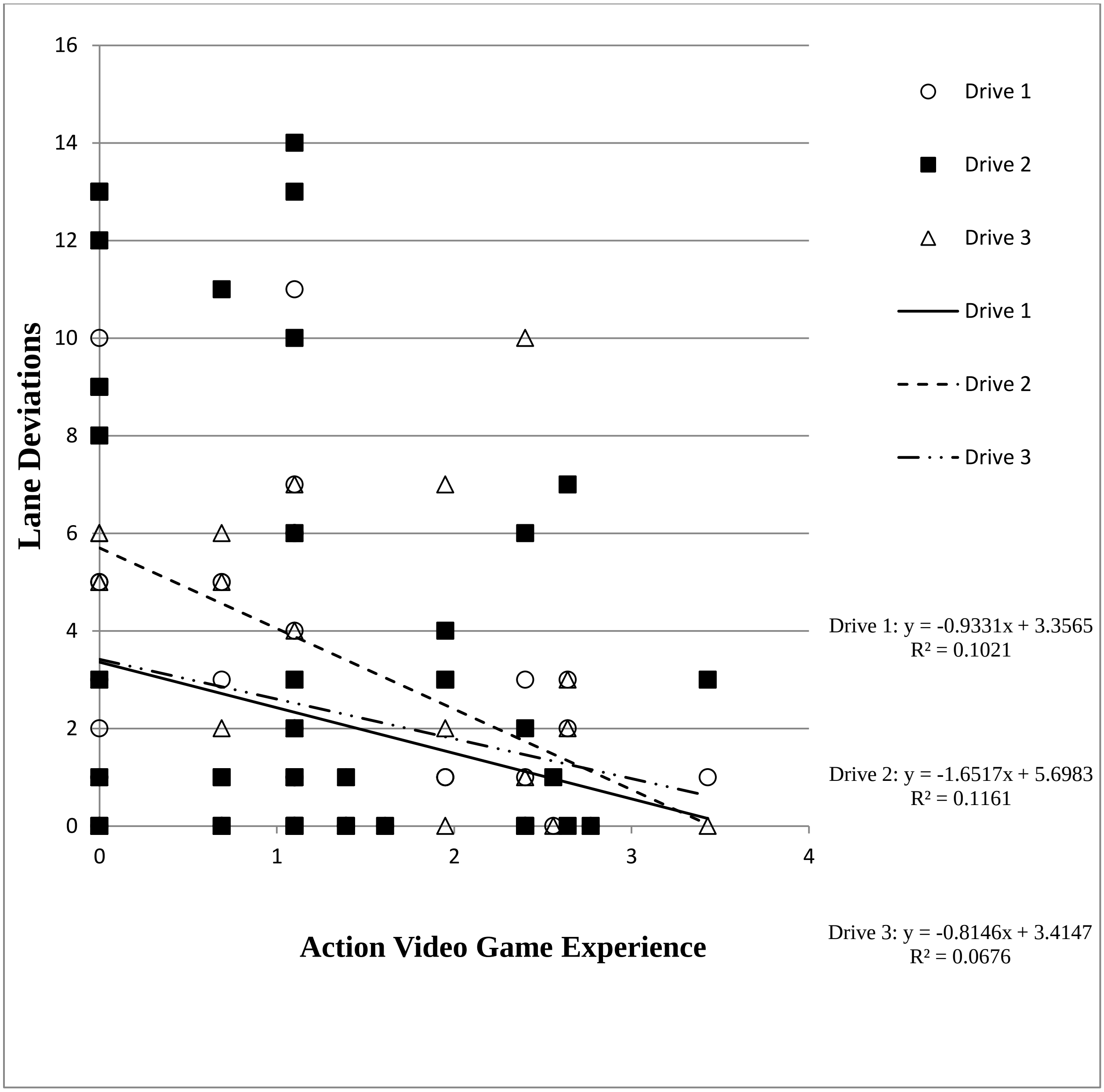

Figure 8: Regression of AVG experience on lane deviations

Research Question 4

Since AVG play was significant for both spatial abilities and lane deviations, another hierarchical linear regression was utilized to determine if individual differences in spatial abilities alone can explain the findings for lane deviations. The findings were significant for the interaction between drive condition and spatial abilities, *b* = -.175, T (43) =-3.974, $p < .001$, $R^2 = .187$. However, the main effects for spatial ability was not significant, *b* = -.071, T (43) =-1.626, $p > .05$.

Table 4: Spatial abilities and lane deviations

Variable	*B*	*SE B*	*ß*	*t*	R^2
Spatial Abilities	-0.071	0.044	-0.223	-1.626	
Interaction	-0.175	0.044	-0.58	-3.974**	0.187

** P < .05; ** P <.001*

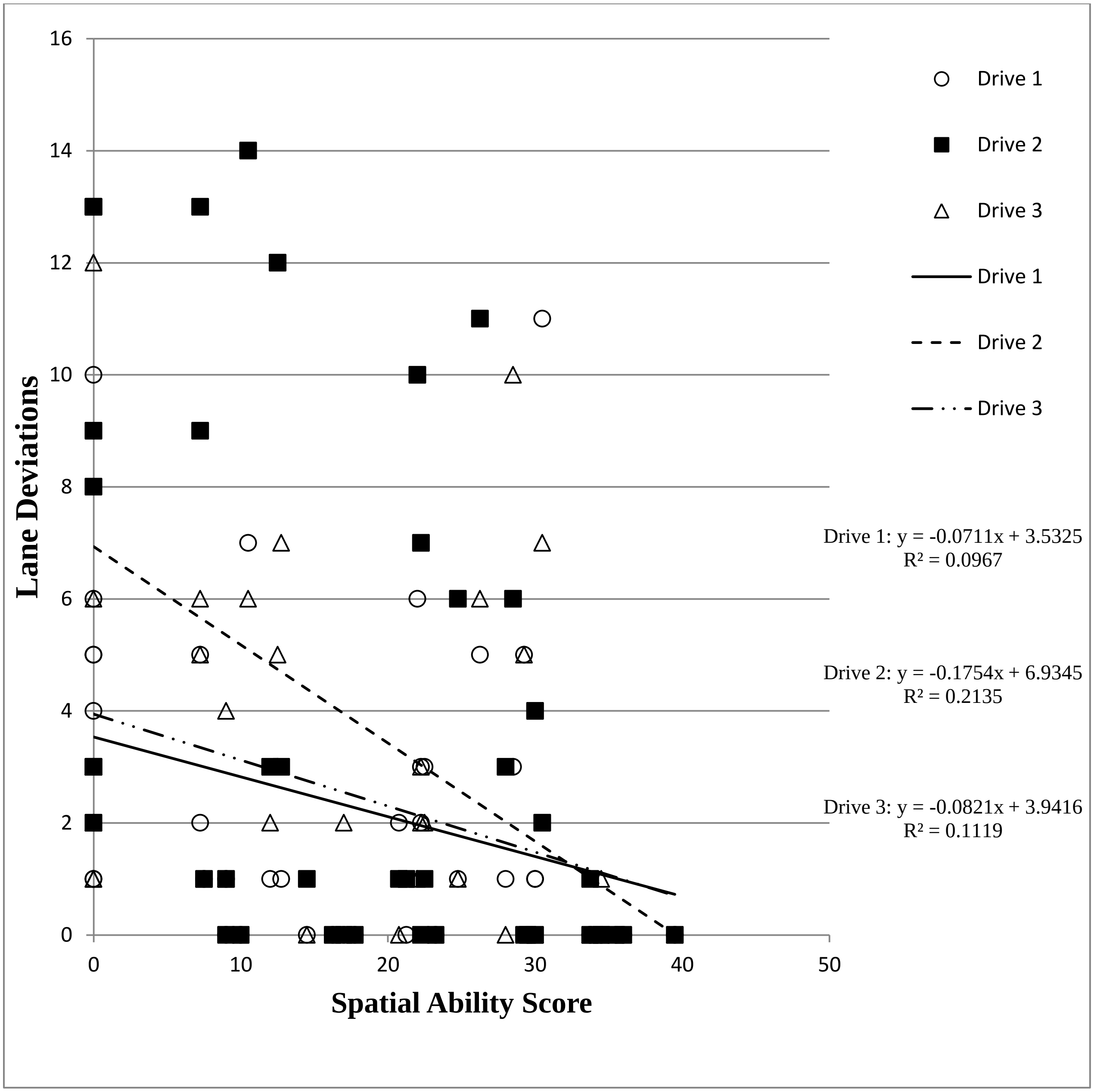

Figure 9: Regression between spatial ability scores and lane deviations

CHAPTER FIVE: DISCUSSION

Summary

In summary, action video games (AVGs) are complex activities, like driving, which require many subordinate sensory tasks that include visual, cognitive, auditory, and manual (motor) aspects. Furthermore, previous Action Video Game (AVG) research has been mixed showing both significant and non-significant effects of game experience on research tasks. Some researchers suggest and have shown in both correlational and experimental studies that AVG experience makes substantial differences in both visual and cognitive systems. Bavelier (2011) stated that playing action games will cause players to improve their vision, attentional resources, and situational awareness across all age ranges even if the players do not like playing them. Additionally, the researcher states that these gamers should show improved divided attention skills such as completing a phone conversation task, monitoring the location of cars on the road as well as show improved performance on the lane maintenance task of keeping the car within the appropriate lane boundaries. Previous results show a relationship between game experience and skills related to driving. On the other hand, research has also shown that video game experience, specifically, action game experience makes people better only at playing video games (Boot et al., 2008). Furthermore, those researchers found that the aforementioned skills do not transfer to other tasks such as driving. Additionally, if skill transfer is identified, it was shown to be a very narrow transfer, meaning it only affects tasks that are of high similarity to the games themselves (Boot, et al. 2010; Durlach et al., 2009; Murphy & Spencer 2009).

Explanation of the results

The current study had both experimental and correlational elements; the experimental elements consisted of a repeated measures driving distraction study. All participants in the study were given a control drive, distraction drive, and followed up by another control drive. From this standpoint, the results have the ability to replicate previous driving distraction studies where the results could show a causal relationship between the distraction and driving performance. Based on previous results, it was hypothesized that the conversation would significantly lower driving performance and increase workload on the drivers. The results indicated that both the subjective reports of workload and the objective measures of lane deviations showed significance for distraction. Participants reported significantly higher amounts of workload in the distraction condition than they did in the control drives. In addition, participants had significantly more lane deviations in the distraction condition than the control conditions. This hypothesis was supported and the results replicated the findings that performing a phone conversation while driving will cause a decrement in driving performance due to an over allocation of attentional resources. The addition of the verbal conversation to the driving task caused the level of cognitive workload to surpass the amount of available resources and thus caused the participants to limit the amount of attention given to the driving task (Caird et al., 2008; Horrey & Wickens, 2006; Strayer et al., 2001; Strayer & Drews, 2007).

The correlational element of the study was the introduction of the video game experience measure, which was added in order to determine if a relationship exists between game experience and driving performance. Participants who reported a higher level of video game experience also scored higher on the spatial ability tests. Schuster, et al. (2008) showed positive correlations between overall video game experience and spatial ability scores as well as increased performance operating unmanned vehicles in a simulated environment. However, as promising as these results may be they do not show a causal factor. It may be that these results show that playing action video games or video games overall does not improve spatial abilities, but instead that those who like to play video games may have higher spatial abilities. In other words, higher spatial abilities may be a trait of video gamers and not a cause of the abilities. ESA (2010) stated that the most popular game category for 2010 was the action genre. Ozdamli, et al. (2011) surveyed 4,823 high school students and found that 47% respondents preferred playing action games, both forms of action games; therefore it is logical that participants who played more video games in general also played action games. Additionally, the participant's spatial ability scores were more closely related to the driving measure of lane deviations than the video game measures were. The results showed that the spatial ability measure significantly accounted for 10.1% more variance than the action game measure did for lane deviations. Moreover, the regression model for action game experience was not significant over and above the spatial ability measure. This indicates that the participants' objective performance was more closely related to the spatial ability measure instead of the amount of video game play. This supports the self-selection hypothesis of video game players as referenced in Boot, et al. (2011); Erikson, et al. (2010); and Spence & Feng (2010).

The results further showed an interaction between the distraction drive and spatial ability for lane deviations, but not a main effect for spatial ability. Lane deviations increased for those with lower spatial ability scores in the distraction condition, while those with higher spatial ability scores remained unchanged. Maintaining lateral position within a lane is a spatial task. Drivers' must direct attention to both knowing their own vehicle position and keep it from reaching the boundaries of the lane. One possible explanation for the interaction, but not a main effect is that for those who score higher on spatial orientation and visualization skills, maintaining lane position is more of an automatic task. Therefore, during the conversation those participants had resources to allocate to both the conversation and lane maintenance tasks and thus had higher dual task performance.

Furthermore, there was a significant negative relationship between action game experience and lane deviations for all drives. The results indicated that 11.2% of the variance is explained by the effect; however, although there was a main effect for game experience, there was not a significant interaction between game experience and driving condition. This indicates that while those with higher game experience had fewer lane deviations across all drives they were just as distracted by the conversation as those with no or lower action game experience. Additionally, the data showed non-significant findings on the cognitive failures questionnaire (CFQ) for both total score and all subscales of the test (Memory, Distractibility, Blunders, and Names). Past research has shown a positive relationship between this questionnaire and driving errors as well as failures of attention. Lack of significance on these measures substantiates the results that participants' with higher action game experience do not show improved attentional capacity or the ability to better allocate their attention than non-players do. It was hypothesized that players with more AVG experience would score significantly better on this questionnaire and that the data would show a significant interaction effect for AVG experience and drive condition on lane deviations which was not supported by the data. Furthermore, it was hypothesized that participants with more action game experience would report a lower amount of workload in the distraction condition; the data also failed to support this finding. The main effect for game experience indicates that those individuals with more experience playing video games were better at driving in the simulator. The driving environment is a simulated environment; therefore, it has elements in common with a video game, which may have accounted for the improvement across all driving conditions.

Limitations

The study had the following limitations. Some of the effect sizes yielded relatively smaller significant results than were expected from the review of the literature. There are several possible reasons for this. First, participants were asked to rate AVG experience for the last 6 months. However, due to the issues in measuring objective self-reported hours of play, the participants' responses may not represent their true number of game play hours. Secondly, the mean ages of participants were 20.22 and only male participants were selected for this study, the results may be different for females or older age groups not studied in this study. Finally, it may be that the hypothesis that AVG skills, although significant in simulated environments and laboratory tests, may not transfer to tasks outside of these domains.

Directions for Future Research

Although this study’s findings support the research that action video games do not increase players’ ability to better allocate attention or have an overall greater capacity of attention than non-players video games, it may still be able to play an important part in research. Video games contain elements that people find engaging, motivating, and provide enjoyment (McGonagall, 2011). These elements may be able to increase motivation, learning and adherence to training as suggested in McLaughlin et al. (2012), McKay and Maki (2010), & Kato (2010) when either games or game like elements are incorporated into traditional training techniques. Younger and older adults are both populations that may benefit from such interventions. Younger adults have accidents due to inexperience and older adults have crashes due to reductions in physical capabilities (Gentzler & Smither, 2012; Mayhew et al., 2002; Romoser & Fisher, 2009). Therefore, different training techniques would be needed for each population, however, both populations have rated video games favorably and attempts to create serious games that assist in the development driving skills shows promise (Backlund, Engström, & Johannesson, 2006; Ozdamli et al., 2011; McLaughlin et al., 2012; Mckay & Maki, 2010).

Additionally, future research can examine, to what extent the game experience measure is related to performance in simulated or virtual environments. If so, video game experience may be useful as selection criteria or prerequisite for training in simulated environments. Schuster, et al. (2008) demonstrated that increased game experience correlated with increased performance on a spatial task in a simulated environment. This study showed similar findings since both higher spatial abilities scores were linked to better performance on a complex task that caused participants' cognitive resources to be taxed and those with higher game experience demonstrated better performance in the simulated environment. Future studies could tease apart these findings.

Future research will focus on the specific effect of spatial ability found in this study. Participants were not specifically recruited for spatial ability or trained to have improved spatial abilities. One specific future study could follow up on determining how higher spatial ability skills affect cognitive resources while performing spatial tasks. Another study could examine the correlation between spatial abilities and gaming habits. Spatial abilities not gaming experience improved resistance to distraction during the driving task. Another question to research in future studies is does spatial abilities explain some of the results found in other studies.

Finally, McGonigal (2011) stated that a game should always push the player to the edge of his or her skill level. This can be accomplished by creating an adaptive environment, which constantly challenges the player. However, games also include elements that encourage prolonged play and players often would rather continue playing the game than reach the end of that game. The elements that are used to increase playtime include large open-ended sections that have few clues to direct players to the next part of the game and objects that are used to increased immersion such as decorative objects that allow for player interaction. These elements create ambiguous situations where the player has to learn the rules and the feedback system of the game (McGonigal, 2011). These elements may increase overall playtime of the game, however, during these times, the player is not being tested, challenged, and they are not utilizing any visual or cognitive skills that action games require (Green & Bavelier, 2003). Furthermore, when researchers bring video gamers into the lab for correlational studies, players are commonly asked how many hours per week do that individual play action games. However, if that player answers 18 hours per week and then spends 15 hours learning how to play the game or exploring the game environment and only 3 hours actually playing the game at his or her skill level, his or her experience playing the game should only be rated at 3 hours. This may be an extreme case however; it poses a possible confounding variable for correlational game research. Moreover, this issue may be seen in correlational studies, but not in training studies since the players' experiences would be controlled in lab settings, where, correlational studies rely on self-reports or experience. Therefore, this issue may be addressed in future correlational studies by asking participants both how much experience does that player have playing games, but also to break that experience down into experience playing competitively and experience spent in game overall.

Conclusions

The findings of this study have the following theoretical implications. Primarily, it adds support to the idea that skills garnered from playing action video games do not transfer to tasks, which are dissimilar to the action games, such as performing complex tasks in the presence of distractions. The degree to which training is similar to the task being trained identifies how likely the training will transfer to task improvements. Training on one task is not likely to transfer to a completely different task (Boot et al., 2011; Yamnill & McLean, 2001). The skills gained through action game play may improve game-like tasks, or some psychometric tasks, but not tasks that are unrelated (Boot, 2008; Durlach et al., 2009; Green & Bavelier 2003; 2007; 2010).

The findings of this study also have practical applications. The results found that 92% of participants stated a preference for action video games. This finding supported McKay & Maki (2010) and McLaughlin (2012) research statements. Elements from video games may improve training due to their ability to increase interest and motivation toward training and not for their ability to transfer skills.

APPENDIX A: UCF IRB LETTER

University of Central Florida

University of Central Florida Institutional Review Board
Office of Research & Commercialization
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: 407-823-2901 or 407-882-2276
www.research.ucf.edu/compliance/irb.html

Approval of Human Research

From: **UCF Institutional Review Board #1**
FWA00000351, IRB00001138

To: **Michael A. Rupp**

Date: **November 30, 2011**

Dear Researcher:

On 11/30/2011 the IRB approved the following human participant research until 11/29/2012 inclusive:

Type of Review:	UCF Initial Review Submission Form Expedited Review Category #4 and 7 *This approval includes a Waiver of Written Documentation of Consent*
.Project Title:	ANALYZING ACTION GAME PLAYERS' PERFORMANCE DURING DISTRACTED DRIVING
Investigator:	Michael A. Rupp
IRB Number:	SBE-11-07992
Funding Agency:	
Grant Title:	
Research ID:	N/A

The Continuing Review Application must be submitted 30days prior to the expiration date for studies that were previously expedited, and 60 days prior to the expiration date for research that was previously reviewed at a convened meeting. Do not make changes to the study (i.e., protocol, methodology, consent form, personnel, site, etc.) before obtaining IRB approval. A Modification Form cannot be used to extend the approval period of a study. All forms may be completed and submitted online at https://iris.research.ucf.edu .

If continuing review approval is not granted before the expiration date of 11/29/2012, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

Use of the approved, stamped consent document(s) is required. The new form supersedes all previous versions, which are now invalid for further use. Only approved investigators (or other approved key study personnel) may solicit consent for research participation. Participants or their representatives must receive a copy of the consent form(s).

In the conduct of this research, you are responsible to follow the requirements of the Investigator Manual.

On behalf of Sophia Dziegielewski, Ph.D., L.C.S.W., CF IRB Chair, this letter is signed by:

Signature applied by Joanne Muratori on 11/30/2011 02:32:00 PM EST

Joanne Muratori

IRB Coordinator

APPENDIX B: SIMULATOR QUESTIONS

1. Tell me about one of your favorite childhood memories.
2. If you had one million dollars, how would you spend it?
3. If you can go back and change one thing in your life what would it be?
4. What would your dream house look like?
5. What is the most fun you have had in the last year?
6. Tell me about the most interesting place you have ever been?
7. What was the last movie that you saw in a theater?
8. Tell me about a time that you went somewhere you have never been before?
9. What did you do last Tuesday?
10. If you could have any job, what would it be?
11. What are three things you could not live without and why?
12. If you only had 24 hours to live what would you do?
13. What is the 20th letter in the Alphabet?
14. Where would you most like to visit and why?
15. If you were stranded on a desert island, what three items would you bring with you and why?
16. Please recite the Alphabet backwards (Z-A)
17. Can money buy happiness, why?
18. If you had to move to another state where would it be and why?
19. Give me directions from your current location to the student union building?
20. List the last five presidents of the U.S.A?
21. List the last five vice presidents of the United States?
22. What are you doing to do with your degree when you graduate?
23. If you were to be remembered for one thing, what would you like it to be?
24. If you were invisible for a day, what would you do?
25. If the whole world were listening what would you say?

APPENDIX C: VIDEO GAME EXPEREINCE QUESTIONNAIRE

Research has shown that Video Game experience is related to motion sickness and some games are closer related more than others to this construct are. In addition to the previous questions about your motion history, we would like to know about your experience playing video games in order to fully understand your risk of sickness during the experiment. Please answer the questions below and for each question select the appropriate choice, which most accurately describes your experience. Answer questions independently in the order that they appear. Do not skip questions or return to a previous question to change your answer.

Do you play?

	Yes	No
Video Games on a Computer	○	○
Video Games on a Console (Xbox, PlayStation, Nintendo, etc...)	○	○

How many hours per week do you play video games on average in the last 6 months? (Enter the closest whole number) _________

How much do you prefer to play the following types of games? (You may select multiple answers.)

	Very Strongly Avoid	Strongly Avoid	Avoid	Indifferent	Prefer	Strongly Prefer	Very Strongly Prefer
Puzzle games (e.g. Minesweeper, Tetris)	☐	☐	☐	☐	☐	☐	☐
Adventure Games (e.g. Myst)	☐	☐	☐	☐	☐	☐	☐
Real-time strategy games (e.g. Command and Conquer, Starcraft)	☐	☐	☐	☐	☐	☐	☐
Driving games non/semi realistic (e.g. Need for Speed, Burnout, GTA)	☐	☐	☐	☐	☐	☐	☐
Driving Sims Realistic (e.g. Grand Turismo, Dirt, other realistic driving games)	☐	☐	☐	☐	☐	☐	☐
Non-Driving Simulations (e.g. Flight SIM, Sims	☐	☐	☐	☐	☐	☐	☐
First-person shooters (e.g. Counter-Strike, Call of Duty, Halo)	☐	☐	☐	☐	☐	☐	☐
Massively multiplayer online role-playing games(MMORPG) (e.g. World of Warcraft, Star Wars Galaxy)	☐	☐	☐	☐	☐	☐	☐
Fighting (e.g. Street Fighter,	☐	☐	☐	☐	☐	☐	☐

Mortal Kombat)							
Sports (e.g. Madden, NBA, NHL)	☐	☐	☐	☐	☐	☐	☐
Social networking games (e.g. Facebook/Myspace games, Farmville Mafia Wars)	☐	☐	☐	☐	☐	☐	☐
Other Action Games (Assasins Creed, Gears of War, Resident Evil)	☐	☐	☐	☐	☐	☐	☐
Music (Rockband, Guitar hero)	☐	☐	☐	☐	☐	☐	☐
Other ________	☐	☐	☐	☐	☐	☐	☐
Other ________	☐	☐	☐	☐	☐	☐	☐
Role-Playing Games (Final Fantasy...)	☐	☐	☐	☐	☐	☐	☐

How much do you play the following types of games?

	Please List the Average hours that you play per week (closest whole number) for each type of game listed below	Please list your Expertise with each game genre with 1 being very low expertise and 5 being very high expertise
Puzzle games (e.g. Minesweeper, Tetris)		
Adventure Games (Myst etc...)		
Real-time strategy games (e.g. Command and Conquer, Starcraft)		
Driving games non/semi realistic (e.g. Need for Speed, Burnout, GTA)		
Driving Sims Realistic (e.g. Grand Turismo, Dirt, other realistic driving games)		
Non-Driving Simulations (MS Flight SIM, Sims)		
Aggressive games (e.g. Grand Theft Auto, Saints Row)		
Action Video Games: (Fallout, Halo, Call of Duty, Assassins Creed, Splinter Cell, Gears of War, Resident Evil, BioShock, Mass Effect. Most First and third person shooters generally qualify as action games)		
Massively multiplayer online role-playing games(MMORPG) (e.g. World of Warcraft, Star Wars Galaxy)		
Fighting (Street Fighter, Mortal Kombat, Soul Caliber)		
Sports (Madden, NBA, NHL)		

Social networking games (Facebook/Myspace games, Farmville Mafia Wars)		
Music (Rockband, Guitar hero, Amplitude, etc...)		
Other ___________		
Other ___________		
Other ___________		
Role-Playing Games (Final Fantasy, Lost Odyssey, Eternal Sonata...)		

What six video games have you played the most in the last 3 months? (If you have not played at least 6 games, you may list fewer, just put NA in the remaining fields)

Game 1 __________________
Game 2 __________________
Game 3 __________________
Game 4 __________________
Game 5 __________________
Game 6 __________________

What six video games have you played the most in the last 3-6 months? (If you have not played at least 6 games, you may list fewer, just put NA in the remaining fields)

Game 1 __________________
Game 2 __________________
Game 3 __________________
Game 4 __________________
Game 5 __________________
Game 6 __________________

REFFERENCES

Adler, LA, Kessler, RC, & Spencer, T. (2003). Adult ADHD Self-Report Scale-v1. 1 (ASRS-v1. 1) Symptom Checklist. *New York, NY: World Health Organization*.

Achtman, R., Green, C., & Bavelier, D. (2008). Video games as a tool to train visual skills. *Restorative neurology and Neuroscience, 26*(4), 435-446.

Applegate, R., & Massof, R. (1975). Changes in the contrast sensitivity function induced by contact lens wear. *American journal of optometry and physiological optics, 52*(12), 840.

Atchley, P., & Dressel, J. (2004). Conversation Limits the Functional Field of View. *Human Factors, 46*(4), 664-673.

Bailey, K., West, R., & Anderson, C. A. (2010). A negative association between video game experience and proactive cognitive control. *Psychophysiology, 47*(1), 34-42.

Ball, K. K., Wadley, V. G., & Edwards, J. D. (2002). Advances in technology used to assess and retrain older drivers. *Gerontechnology, 1*(4), 251-261.

Backlund, P., Engström, H., & Johannesson, M. (2006, December, 1). *Computer gaming and driving education.* Paper presented at the Workshop Pedagogical Design of Educational Games affiliated to the 14th International Conference on Computers in Education (ICCE 2006), Beijing, China.

Barkana, Y., Zadok, D., Morad, Y., & I., A. (2004). Visual Field Attention Is Reduced by Concomitant Hands-free Conversation on a Cellular Telephone. *American journal of ophthalmology, 138,* 347-352. DOI: 10.1016/j.ajo.2004.04.016.

Bavelier, D., Green, C. S., & Dye, M. W. G. (2010). Children, wired: For better and for worse. *Neuron, 67*(5), 692-701.

Bavelier, D. (2011). *Myth: Drivers Need to Stay Focused*. Paper presented at the Edmunds' Safety Conference: Truly Safe? Debunking Myths and Crafting Effective Policies for Car Safety, Washington, DC.

Beede, K., & Kass, S. (2006). Engrossed in conversation: The impact of cell phones on simulated driving performance. *Accident analysis and Prevention, 38*, 415-421.

Beninger, R., & Miller, R. (1998). Dopamine D1-like Receptors and Reward-related Incentive Learning. *Neuroscience & Biobehavioral Reviews, 22*(2), 335-345.

Berridge, K. C., & Robinson, T. E. (1998). What is the role of dopamine in reward: hedonic impact, reward learning, or incentive salience? *Brain Research Reviews, 28*(3), 309-369.

Blumen, H. M., Gopher, D., Steinerman, J. R., & Stern, Y. (2010). Training cognitive control in older adults with the Space Fortress game: the role of training instructions and basic motor ability. *Frontiers in aging neuroscience, 2*.

Boot, W., Kramer, A., Simons, D., Fabiani, M., & Gratton, G. (2008). The Effects of Video Game Playing on Attention, Memory, and Executive Control. *Acta Psychologica*, *129,* 387-398.

Boot, W. R., Basak, C., Erickson, K. I., Neider, M., Simons, D. J., Fabiani, M., Lee, H. K. (2010). Transfer of skill engendered by complex task training under conditions of variable priority. *Acta psychologica, 135*(3), 349-357.

Boot, W. R., Blakely, D. P., & Simons, D. J. (2011). Do action video games improve perception and cognition? *Frontiers in psychology, 2*.

Broadbent, D. E., Cooper, P. F., FitzGerald, P., & Parkes, K. R. (1982). The cognitive failures questionnaire (CFQ) and its correlates. *British Journal of Clinical Psychology*, *21*(1), 1-16.

Buck, D.S. (1957). Driver Testing and Training. *Traffic Quarterly*, *11*(4).

Cain, M. S., Landau, A. N., & Shimamura, A. P. (2012). Action Video Game Experience Reduces the Cost of Switching Tasks.

Caird, J. K., Willness, C. R., Steel, P., & Scialfa, C. (2008). A meta-analysis of the effects of cell phones on driver performance. *Accident Analysis & Prevention, 40*(4), 1282-1293.

Caplovitz, G., & Kastner, S. (2009). Carrot sticks or joysticks: video games improve vision. *Nature Neuroscience, 12*(5), 527- 528.

Carroll, J. (1993). Abilities in the Domain of Visual Perception *Human Cognitive Abilities* (pp. 304-362). New York, NY: Cambridge University Press.

Cherney, I. (2008). Mom, Let Me Play More Computer Games: They Improve My Mental Rotation Skills. *Sex Roles, 59*, 776-786. DOI: 10.1007/s11199-008-9498-z

Chisholm, J. (2010). Reduced Attentional Capture in Action Video Game Players. *Attention, Perception, & Psychophysics, 72*(3), 667-671. DOI: 10.3758/APP.72.3.667

Deutsch, J. A., & Deutsch, D. (1963). Attention: Some theoretical considerations. *Psychological Review, 70*(1), 80.

Donchin, E. (1995). Video games as research tools: The Space Fortress game. *Behavior Re-*

search Methods, 27(2), 217-223.

Dos Santos, C. (2007). *Assessment of the Safety Benefits of VMS and VSL using the UCF Driving Simulator.* Masters of Science, University of Central Florida Orlando, Florida, Orlando, FL.

Drews, F., & Strayer, D. (2009). Cellular Phones and Driver Distraction. In M. Regan, J. Lee & K. Young (Eds.), *Driver Distraction Theory Effects and Mitagation*. Boca Raton, FL.

Durlach, P., Kring, J., & Bowens, L. (2009). Effects of Action Video Game Experience on Change Detection. *Military Psychology*(21), 24-39. doi: 10.1080/08995600802565694

Dye, M. W. G., Green, C., & Bavelier, D. (2009a). The development of attention skills in action video game players. *Neuropsychologia, 47*(8-9), 1780-1789.

Dye, M. W. G., Green, C. S., & Bavelier, D. (2009b). Increasing speed of processing with action video games. *Current DIrections in Psychological Science, 18*(6), 321-326.

Electronic Software Association (ESA) (2011). Essential Facts: About the Computer and Video Game Industry. Retrieved Feburary, 13, 2011, from http://www.theesa.com/facts/pdfs/ESA_Essential_Facts_2010.PDF

Ekstrom, R. B., French, J. W., Harman, H. H., & Dermen, D. (1976). Manual for kit of factor-referenced cognitive tests. *Princeton, NJ: Educational Testing Service*.

Endsley, M. R. (1995). Toward a theory of situation awareness in dynamic systems. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 37*(1), 32-64.

Engström, J., Johansson, E., & Östlund, J. (2005). Effects of visual and cognitive load in real and simulated motorway driving. *Transportation Research Part F, 8*, 97-120.

Erickson, K. I., Boot, W. R., Basak, C., Neider, M. B., Prakash, R. S., Voss, M. W., . . . Gratton, G. (2010). Striatal volume predicts level of video game skill acquisition. *Cerebral Cortex, 20*(11), 2522-2530.

Fery, Y. A., & Ponserre, S. (2001). Enhancing the control of force in putting by video game training. *Ergonomics, 44*(12), 1025-1037.

Fincannon, T., Evans, A. W., Jentsch, F., & Keebler, J. (2008). *Constructs of Spatial Ability and Their Influence on Performance with Unmanned Systems*. Paper presented at the Human Factors Issues in Imagery Analysis using Unmanned Aerial Vehicles, Gold Canyon, AZ.

Fisk, A. D., & Schneider, W. (1981). Control and automatic processing during tasks requiring sustained attention: A new approach to vigilance. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 23*(6), 737-750.

Fisher, D.L., Rizzo, M., & Caird, J. (2011). *Handbook of driving simulation for engineering, medicine, and psychology*. Boca Raton, FL: CRC Press.

Gentzler, M.D., & Smither, J.A. (2012). A literature review of major perceptual, cognitive, and/or physical test batteries for older drivers. *Work: A Journal of Prevention, Assessment and Rehabilitation, 41*, 5381-5383.

Goldstein, E. B. (2010). *Sensation and perception* (9th ed.). Belmont, CA.: Wadsworth Pub Co.

Governors Highway Safety Association (GHSA). (2011). Distracted Driving What Research Shows and What States Can Do (Vol. 2011). Washington, DC.

Green, M., Allen, M. J., Abrams, B. S., & Weintraub, L. (2008). *Forensic Vision: With Application to Highway Safety*. Tucson, AZ.: Lawyers & Judges Publishing.

Green, C., & Bavelier, D. (2003). Action Video Game Modifies Visual Selective Attention. *Nature, 423*, 534-537.

Green, C., & Bavelier, D. (2008). Exercising your brain: a review of human brain plasticity and training-induced learning. *Psychology and Aging; Psychology and Aging, 23*(4), 692.

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature, 423*(6939), 534-537.

Green, C. S., & Bavelier, D. (2006). Effect of action video games on the spatial distribution of visuospatial attention. *Journal of experimental psychology: Human perception and performance, 32*(6), 1465.

Green, C. S., & Bavelier, D. (2007). Action-video-game experience alters the spatial resolution of vision. *Psychological Science, 18*(1), 88-94.

Green, C. S., Li, R., & Bavelier, D. (2010). Perceptual learning during action video game playing. *Topics in Cognitive Science, 2*(2), 202-216.

Groeger, J. A. (2000). *Understanding driving: Applying cognitive psychology to a complex everyday task*. Philadelphia, PA.: Taylor & Francis inc.

Hart, S. G. (2006). *NASA-task load index (NASA-TLX); 20 years later.* Paper presented at the Human Factors and Ergonomics Society 50th Annual Meeting, San Francisco, CA.

Hart, S. G., & Staveland, L. E. (1988). Development of the NASA-TLX(Task Load Index). In P. A. Hancock & N. Meshkati (Eds.), *Human Mental Workload*. Amsterdam: North Holland Press.

Horrey, W. J., & Wickens, C. D. (2003). *Multiple resource modeling of task interference in vehicle control, hazard awareness and in-vehicle task performance*.

Horrey, W. J., & Wickens, C. D. (2006). Examining the impact of cell phone conversations on driving using meta-analytic techniques. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 48*(1), 196-205.

James, W. (1890). 1950) The Principles of Psychology: New York: Dover Publications.

Jäncke, L., & Klimmt, C. (2011). Expertise in Video Gaming and Driving Skills. *Zeitschrift für Neuropsychologie, 22*(4), 279-284.

Jerome, C., Ganey, N., Mouloua, M., & Hancock, P. (2002). Driver Workload Response to In-Vehicle Device Operatons. *International Journal of Occupational Saftey and Ergonamics, 8*(4), 539-578.

Kahneman, D. (1973). *Attention and effort*. Englewood Cliffs, NJ: Prentice Hall.

Kapur, S. (2003). Psychosis as a State of Aberrant Salience: A Framework Linking Biology, Phenomenology, and Pharmacology in Schizophrenia. *American Journal of Pychiatry, 160*, 13-23.

Kato, P. M. (2010). Video games in health care: Closing the gap. *Review of General Psychology, 14*(2), 113.

Kaufman, S. B. (2007). Sex differences in mental rotation and spatial visualization ability: Can they be accounted for by differences in working memory capacity? *Intelligence, 35*(3), 211-223.

Kennedy, R.S., Fowlkes, J.E., Berbaum, K.S., & Lilienthal, M.G., (1992). Use of a motion sickness history questionnaire for prediction of simulator sickness. *Aviation Space Environmental Medicine, 63*, 558-593.

Kennedy, R.S., Lane, N.E., Berbaum, K.S., & Lilienthal, M.G., (1993). Simulator sickness questionnaire: An enhanced method for quantifying simulator sickness. *International Journal of Aviation Psychology, 3,* 203-220.

Klauer, S., Dingus, T., Neale, V., Sudweeks, J., & Ramsey, D. (2006). The impact of driver inattention on near-crash/crash risk: An analysis using the 100-car naturalistic driving study data. *Analysis*(April).

Koepp, M., Gunn, R., Lawrence, A., Cunningham, V., Dagher, A., Jones, T., . . . Grasby, P. (1998). Evidence for striatal dopamine release during a video game. *Nature, 393*(6682), 266-267.

Larson, G. E., & Merritt, C. R. (1991). Can accidents be predicted? An empirical test of the Cognitive Failures Questionnaire. *Applied Psychology, 40*(1), 37-45.

Lee, J. D. (2008). Fifty years of driving safety research. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 50*(3), 521-528.

Leibowitz, H.W., and Post, R.B. (1982). The two modes of processing concept and some implications. In J. Beck (Ed.), *Organization and representation in perception* (pp. 343–363). Hillsdale, NJ: Lawrence Erlbaum.

Li, R., Polat, U., Makous, W., & Bavelier, D. (2009). Enhancing the contrast sensitivity function through action video game training. *Nature Neuroscience, 12*(5), 549-551.

Maclin, E. L., Mathewson, K. E., Low, K. A., Boot, W. R., Kramer, A. F., Fabiani, M., & Gratton, G. (2011). Learning to multitask: Effects of video game practice on electrophysiological indices of attention and resource allocation. *Psychophysiology, 48*(9), 1173-1183.

Madden, M., & Rainie, L. (2010). Adults and Cell Phone Distractions *Pew Internet & American Life Project* (pp. 1-12). Washington, D.C.: Pew Research Center.

Mane, A., & Donchin, E. (1989). The space fortress game. *Acta psychologica, 71*, 17-22.

Mayhew, D.R., Simpson, H.M., & Pak, A. (2003). Changes in collision rates among novice drivers during the first months of driving. *Accident Analysis & Prevention, 35*(5), 683-691.

McCarley, J. S., Vais, M. J., Pringle, H., Kramer, A. F., Irwin, D. E., & Strayer, D. L. (2004). Conversation disrupts change detection in complex traffic scenes. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 46*(3), 424-436.

McGee, M. G. (1979). Human spatial abilities: Psychometric studies and environmental, genetic, hormonal, and neurological influences. *Psychological bulletin, 86*(5), 889.

McGonigal, J. (2011). *Reality is broken: Why games make us better and how they can change the world*: Penguin Pr.

McKay, S., & Maki, B. (2010). Attitudes of older adults toward shooter video games: an initial study to select an acceptable game for training visual processing. *Gerontechnology, 9*(1), 1-17.

McLaughlin, A., Gandy, M., Allaire, J., & Whitlock, L. (2012). Putting Fun into Video Games for Older Adults. *Ergonomics in Design: The Quarterly of Human Factors Applications, 20*(2), 13-22.

Michaelis, J. (2011). *The effects of attention deficit hyperacticity disorder on fixations and saccades during a simulated driving task.* Psychology B.A., University of Central FLorida, Orlando, FL.

Mishra, J., Zinni, M., Bavelier, D., & Hillyard, S. A. (2011). Neural basis of superior performance of action videogame players in an attention-demanding task. *The Journal of Neuroscience, 31*(3), 992-998.

Morgan, J., & Hancock, P. A. (2009). Estimations in Driving *Driver Distraction: Theory, Effects, and Mitigation*: Taylor & Francis Group, LLC.

Morris, R. G. (1999). D.O. Hebb: The Organization of Behavior, Wiley: New York; 1949. [Biography. Historical Article]. *Brain Res Bull, 50*(5-6), 437.

Murphy, K., & Spencer, A. (2009). Playing video games does not make for better visual attention skills. *Journal of Articles in Support of the Null Hypothesis, 6*(1), 2.

National Highway Traffic Safety Administration (NHTSA) (2010). Traffic Safety Facts Research Note Publication No. DOT HS 811 372, Washington, DC: U.S. Department of Transportation.

Norman, D. A., & Bobrow, D. G. (1975). On data-limited and resource-limited processes. *Cognitive psychology, 7*(1), 44-64.

Owsley, C., Stalvey, B., Wells, J., & Sloane, M.E. (1999). Older drivers and cataract: Driving habits and crash risk. *Journal of Gerontology. 54*, 203–211.

Ozdamli, F., Bicen, H., & Demirok, M. S. (2011). A Descriptive Study of High School Students Game-Playing Characteristics. *International Journal of Learning and Teaching, 2*(2), 25-33.

Palen, L., Salzman, M., & Youngs, E. (2000). *Going Wireless: Behavior & Practice of New Mobile Phone Users.* Paper presented at the ACM Conference on Computer Supported cooperative work, New York, NY.

Parasuraman, R., & Davies, D. R. (1984). *Varieties of attention*. Orlando, FL: Academic Press.

Parasuraman, R., & Mouloua, M. (1996). *Automation and human performance: theory and applications*. New York, NY: CRC.

Park, J., & Choi, Y. (2007). Brake squeal noise due to disc run-out. *Proceedings of the Institution of Mechanical Engineers, Part D: Journal of Automobile Engineering, 221*(7), 811-821.

Pashler, H. E. (Ed.). (1998). *Attention*. Hove, England: Psychology Press/Erbaum.

Pashler, H., Johnston, J. C., & Ruthruff, E. (2001). Attention and performance. *Annual review of psychology, 52*(1), 629-651.

Regan, M. A., Lee, J. D., & Young, K. L. (2009). *Driver distraction: Theory, effects, and mitigation.* Boca Raton, FL: CRC.

Roenker, D. L., Cissell, G. M., Ball, K. K., Wadley, V. G., & Edwards, J. D. (2003). Speed-of-processing and driving simulator training result in improved driving performance. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 45*(2), 218-233.

Rosenberg, B. H., Landsittel, D., & Averch, T. D. (2005). Can video games be used to predict or improve laparoscopic skills? *Journal of Endourology, 19*(3), 372-376.

Rosenthal, R. (1979). The file drawer problem and tolerance for null results. *Psychological bulletin, 86*(3), 638.

Rosser Jr, J. C., Lynch, P. J., Cuddihy, L., Gentile, D. A., Klonsky, J., & Merrell, R. (2007). The impact of video games on training surgeons in the 21st century. *Archives of Surgery, 142*(2), 181.

Romoser, M., & Fisher, D.L. (2009). *Effects of cognitive and physical decline on older drivers' side-to-side scanning for hazards while executing turns.* Paper presented at the Proceedings of the Fifth International Driving Symposium on Human Factors in Driver Assessment, Training and Vehicle Design, Iowa City, IA.

Saito, K., Mukawa, N., & Saito, M. (2008). Brain Activity Comparison of Different-Genre Video Game Players. *Brain and Development, 28*, 315-321.

Saunders, J.A. & Knill, D.C. (2003). Humans use continuous visual feedback from the hand to control fast reaching movements. Experimental Brain Research, 152(3), 341-352.

Schuster, D., Fincannon, T., Jentsch, F., Keebler, J., & Evans III, A. W. (2008). The Role of Spatial Ability in the Relationship Between Video Game Experience and Route Effectiveness Among Unmanned Vehicle Operators: DTIC Document.

Schwenkreis, P., Tom, S., Ragert, P., Pleger, B., Tegenthoff, M., & Dinse, H. (2007). Assessment of Sensorimotor Cortical Representation Asymmetries and Motor Skills in Violin Players. *European Journal of Neuroscience, 26*, 3291-3302. doi: 10.1111/j.1460-9568.2007.05894.x

Seo, D., & Torabi, M. (2004). The Impact of In-Vehicle Cell-Phone Use on Accidents or Near-Accidents Among College Students. *Journal of American College Health*, *53*(3), 101-108.

Shiffrin, R. M., & Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning, automatic attending and a general theory. *Psychological Review, 84*(2), 127.

Sims, V. K., & Mayer, R. E. (2002). Domain specificity of spatial expertise: The case of video game players. *Applied Cognitive Psychology, 16*(1), 97-115.

Spence, I., & Feng, J. (2010). Video games and spatial cognition. *Review of General Psychology, 14*(2), 92.

Sperling, G. (1960). The information available in brief visual presentations. Psychological Monographs: General and Applied, 74(11), 1-29.

Stern, Y., Blumen, H. M., Rich, L. W., Richards, A., Herzberg, G., & Gopher, D. (2011). Space Fortress game training and executive control in older adults: A pilot intervention. *Aging, Neuropsychology, and Cognition*, *18*(6), 653-677.

Strayer, D., & Drews, F. (2007). Cell-Phone-Induced Driver Distraction. *Current Directions in Psychological Science, 16*(3), 128-131.

Strayer, D., Drews, F., & Johnston, W. (2003). Cell Phone-Induced Failures of Visual Attention During Simulated Driving. *Journal of Experimental Psychology: Applied, 9*(1), 23-32.

Strayer, D., & Johnston, W. (2001). Driven to Distraction: Dual-Task Studies of Simulated Driving and Conversing on a Cellular Telephone. *Psychological Science, 12*(6), 462-466.

Strayer, D. L., & Drews, F. A. (2007). Cell-phone–induced driver distraction. *Current Directions in Psychological Science*, *16*(3), 128-131.

Strayer, D. L., Drews, F. A., & Crouch, D. J. (2006). A comparison of the cell phone driver and the drunk driver. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 48*(2), 381-391.

Stutts, J. C., Reinfurt, D., Staplin, L., & Rodgman, E. (2001). The role of driver distraction in traffic crashes. Washington D.C.: AAA Foundation for Traffic Safety Washington, DC.

Underwood, G., Phelps, N., Wright, C., Van Loon, E., & Galpin, A. (2005). Eye fixation scanpaths of younger and older drivers in a hazard perception task. *Ophthalmic and Physiological Optics, 25*(4), 346-356.

Veeramallu, S. R. (2000). *Collision avoidance systems*. Paper Presented at the MTC Transportation Scholars Conference. Ames, IA.

Wallace, D. B. (2003). External-to-vehicle driver distraction: Scottish Executive Social Research.

Wallace, C.J. (2004). Confirmatory factor analysis of the cognitive failures questionnaire: evidence for dimensionality and construct validity. *Personality and Individual Differences, 37*(2), 307-324.

Wallace, J. C., & Vodanovich, S. J. (2003). Can accidents and industrial mishaps be predicted? Further investigation into the relationship between cognitive failure and reports of accidents. *Journal of Business and Psychology, 17*(4), 503-514.

Walsh, S. P., White, K. M., Hyde, M. K., & Watson, B. (2008). Dialling and driving: Factors influencing intentions to use a mobile phone while driving. *Accident Analysis & Prevention, 40*(6), 1893-1900.

Wickens, C.D., & Hollands, J.G. *Engineering Psychology and Human Performance. 2000* (third ed.). Upper Sadle River, NJ: Pearson/Prentice Hall.

Yamnill, Siriporn, & McLean, Gary N. (2001). Theories supporting transfer of training. *Human Resource Development Quarterly, 12*(2), 195-208. doi: 10.1002/hrdq.7