THE EFFECTS OF VIDEOGAMES ON CLINICAL MEASURES OF ATTENTION, PROCESSING SPEED, AND WORKING MEMORY

A thesis presented to the faculty of the Graduate School of Western Carolina University in partial fulfillment of the requirements for the degree of Specialist in School Psychology.

By

Russell Drew Patton

Director: Dr. Candace Boan-Lenzo

Associate Professor of Psychology

Psychology Department

Committee Members: Dr. Winford Gordon, Psychology

Dr. Erin Myers Psychology

TABLE OF CONTENTS

Page

Abstract ... 3
Chapter I: Introduction ... 4
    Age and Videogame Activity ... 4
    Sex Differences in Videogame Activity ... 6
Chapter II: Literature Review ... 8
    Types of Videogames ... 8
        First-Person or Third-Person Action Games ... 8
        Sports or Racing Games ... 9
        Strategy Games ... 10
        Puzzle or Card Games ... 10
    Videogamer Skills ... 11
    Experimental Visual Attention and Videogames ... 15
    Clinical Attention and Videogames ... 20
    Experimental Reaction Time and Videogames ... 22
    Clinical Processing Speed and Videogames ... 23
    Experimental Working Memory and Videogames ... 24
    Clinical Working Memory and Videogames ... 27
Chapter III: Statement of the Problem ... 29
Chapter IV: Methods ... 32
    Participants ... 32
    Materials ... 32
        Demographics Form ... 32
        Wechsler Adult Intelligence Scale ... 32
        Apparatus ... 34
        Stimulus ... 34
    Procedure ... 34
Chapter V: Results ... 36
    Descriptive ... 36
        Cancellation Task ... 36
        Digit Span ... 36
        Letter-Number Sequencing ... 37
        Symbol Search ... 37
        Coding ... 37
Chapter VI: Discussion ... 39
Chapter VII: Limitations ... 41
Chapter VIII: Directions for Future Research ... 42
References ... 43
Appendix A: Demographic Questionnaire ... 48
Appendix B: Informed Consent ... 51

ABSTRACT

THE EFFECTS OF VIDEOGAMES ON CLINCAL MEASURES OF ATTENTION, PROCESSING SPEED, AND WORKING MEMORY

Russell Patton, SSP

Western Carolina University (November 2014)

Director: Dr. Candace Boan-Lenzo

Videogames are rapidly growing in popularity with people from a wide range of ages enjoying them every day. The main types of videogames are: first-person or third-person action games, sports or racing games, games that require fast visual-motor control, strategy games, and puzzle and card games. Using these videogames, researchers have compared videogame players with non-videogame players in comparative studies and have attempted to train non-videogame players with videogames to see if the same results are present. Certain abilities and skills have been shown to be increased for playing videogames: selective attention, attentional capacity, spatial resolution, contrast sensitivity, reaction times, spatial attention, visual rotation, and visual short term memory.

Because previous research has focused on using a more sedentary activity such as puzzle games, this study used a different visual approach for the control group and measures in which we use an action video that stimulates the same arousal centers in the brain as videogames without actually playing and clinical measures of attention, processing speed, and working memory over more experimental approaches. Participants either played an action videogame or

watched an action movie for 20 minutes and then were tested. Results indicated that there were no significant differences on subtests measured from the Wechsler Adult Intelligence Scale from videogame players and movie watchers.

INTRODUCTION

Videogames are a significant source of revenue and entertainment in today's society (Siwek, 2010). In the most recent entertainment software association report, it was reported that the U.S. computer and videogame software industry directly employs more than 32,000 people in 34 states. In 2009, these employees received a total of 2.9 billion dollars in compensation. The Gross Domestic Product (GDP) of the U.S. computer and videogame software industry was over $4.9 billion. According to the data released by The NPD Group, a global market research company, consumers spent $24.75 billion on videogames, hardware and accessories in 2011. The popularity of videogames has fueled the need for research on the effects of videogames on the physical, social, and psychological functioning of individuals that play them. The next section of this paper will discuss research on the demographics of videogame players and the average amount of time they spend playing games.

Age and Videogame Activity

In the latest Kaiser Family Foundation Media report researchers examined the overall media use of all 8 to 18 year olds and documented, that on average, they are spending seven and a half hours per day on media including: TV content, music / audio, computer, videogames, print, and movies (Rideout, Foehr, & Roberts, 2010). For videogames, it was reported that 60 percent of young people play videogames daily for an average of almost two hours (1:59). Video gaming is highest among teens aged 11 to 14 years old and across all platforms or gaming devices; Hispanic and African American teens play significantly more videogames than White youth. The Kaiser Family Foundation also defined the use of media with regard to heavy, moderate, or light usage. Heavy media users are those who consume more than 16 hours of media content daily (21% of 8 to 18 year olds); moderate users are those who consume 3 to 16 hours of media content daily (63% of 8 to 18 year olds); and light users are those who consume less than three hours of media content daily (17% of 8 to 18 year olds). Heavy media users reported a higher frequency of fair and poor grades (Cs and lower) and were less likely to be getting good grades (As and Bs) than individuals in the moderate to light user categories. Heavy media users also reported being sad or unhappy, being in trouble often, and being bored often more frequently than moderate and light media users.

In a related report from the entertainment software association in 2012, they reported that the average U.S. household owns at least one dedicated game console, PC or smartphone (Siwek, 2010). They also reported that 49 % of U.S. households own a dedicated game console such as Xbox or PlayStation, and households with this type of media typically own an average of 2 consoles. They also reported that the average game player age is 30 with 32 % of game players under the age of 18, 31% between 18 – 35, and 37% 36 and older. The average age of the most frequent game purchaser is 35 with 42 % of those game players believing that computer and videogames give them the most value for their money compared to music, DVDs, or going out to the movies. The next section, we will discuss the research on sex differences in videogame playing.

Sex Differences in Videogame Activity

In U.S. households, males account for 53% of videogame players (Siwek, 2010). While approximately equal numbers of males and females play videogames, there is evidence that males spend more time playing videogames than females. According to the Kaiser Family Foundation Media Report, boys spend 4 times the amount of time playing videogames on a console (:56 minutes) such as Xbox or PlayStation than girls (:14 minutes) (Rideout et al, 2010). For computer gaming, boys spend three times (:24 minutes) as much time daily playing videogames as girls (:8 minutes) between the ages of 8 and 18.

Research has been conducted to determine the types of videogames that males and females prefer to play. Results from research suggest that males play more violent videogames than females (Phan, Jardina, & Hoyle, 2012). However, when females play, they tend to divide their time equally between violent and non-violent videogames. Females were more likely to play puzzles, musical, social, educational, and simulation games than males. In contrast, males played more action, fighting, strategy, and role-playing games compared to females (Phan, Jardina, & Hoyle, 2012).

This following literature review will examine the different types of videogames and explore the relationship between videogame use and cognitive functioning.

LITERATURE REVIEW

Types of Videogames

Sedentary videogames are the traditional form of videogame and require little to no physical movement outside of manipulating joysticks and buttons with your hands. Because sedentary videogame playing requires little to no physical activity and encompasses the vast majority of videogames in today's market, there are pressing health concerns related to sedentary behaviors. These pressing health concerns can potentially be attributed to increased "screen time" which decreases the likelihood of individuals getting enough physical activity. Screen time includes time spent using any form of electronic device with a screen that is innately sedentary (televisions, computers, videogames, tablets, phones) (Russell, 2009).

Not all videogames are created equally and there are many different types and genres. Within the collection of videogames, there are two overarching constructs. Videogames are either sedentary or a form of exergaming. Sedentary videogames only require the player to control the game using a controller or a keyboard, but exergaming requires the use of your whole body as a controller to play the game. Within sedentary games, there are four broad categories or genres that have been studied: first-person or third-person action games, sports or racing games, games that require fast visual-motor control, strategy games, and puzzle and card games (Achtman, Green, & Bavelier 2008).

First-person or third-person action games. First-person or third-person action games include things like *Call of Duty*, *Uncharted,* or *Unreal Tournament*. These types of games require extensive use of your visual attention as players are forced to continuously monitor the screen for unexpected events that need swift and accurate aiming responses. For example, in the

Call of Duty franchise, gamers are positioned in a first-person view where the gamer sees everything through the eyes of the videogame character. In the *Uncharted* franchise, gamers see the main protagonist from a third-person view which has the camera hovering behind the character so you can see him or her and everything around him or her. In both of these games, gamers are required to use their visual attention to monitor when stimulus such as enemies or allies appears on screen and these require different swift actions. As stated above, players need to be able to scan their field of view with increasing quickness as the difficulty gets harder and be able to track moving objects while disregarding distractors. They also depend solely on the player's skill to align motor actions with the detailed world of the game to accurately aim at a small or moving target. Action videogames have varying levels of difficulty and the chance of the game ending because of character death if one is not successful at aiming, tracking, or scanning targets on the screen make them very challenging at different degrees of difficulty.

Sports or racing games. Like action videogames, sports or racing games have varying degrees of difficulty and type within the genre. Sports and racing games both require the gamer to use his or her visual attention to monitor the screen. For sport games such as *FIFA* or *NHL*, gamers have to also be able to use their tracking and scanning skills for not only the player they are controlling, but for their teammates and opponents on the other team. For racing games, the gamer needs to use visual attention to track other racers, obstacles, and objectives in the road. Racing games such as *Grand Turismo* have faster movements and actions, while games such as *FIFA 12* require better scanning processes. Unlike action videogames however, sports and racing games have not been as widely studied in training experiments.

Strategy games. Strategy games such as *Command and Conquer* or *Starcraft* are the fourth category of videogame studied. Strategy games require skills such as memory for where enemies and resources are located and the ability to switch between tasks as the game demands change. For example, the *Command and Conquer* franchise puts the gamer in charge of an army where he or she slowly builds up a headquarters or base by gathering resources and defeating the other enemies on the map. While playing, the gamer has to constantly monitor his or her own resources and the enemy's movements to prepare for an attack. The gamer must formulate a plan of attack to achieve the games objectives, and to create backup plans in case defeat is imminent. These types of games are slower paced, more cognitively focused and do not require quick snap decisions relative to other games. While they do require an individual to track multiple objects and plan his or her tactics, they tend to not be taxing on the visual or cognitive systems (Achtman, Green & Bavelier 2008).

Puzzle or card games. The last category of games studied is card or puzzle games like *Solitaire*, *Hearts*, *Minecraft*, *Minesweeper, and Tetris*. These games typically have two general types: timed and untimed. Timed games require swift visual-motor control but do not require gamers to identify between targets and distractors or require gamers to use their visual attention to aid their motor control for aiming purposes. Games like *Tetris* are significantly different from action videogames in a few aspects. Action videogames are built to hold an individual's attention by introducing unexpected targets that he or she needs to have scanned and then tracked to determine if the target is a distractor such as an ally or a target such as an enemy. Games like Tetris do not have this component as they have a limited number of objects to track at any given time and they are not unpredictable as they come at stratified time periods. Sims and Mayer (2002) also suggested that the shapes in *Tetris* can be memorized to predict spatial configurations and moves unlike an action videogame where it is a very fast paced, changing environment. Untimed games allow the player to take his or her time and decide how to attend to the visual stimuli. Because of the slower pace of the game, responses do not have to be quick or decisive but rather use the player's problem solving and mental imagery to play the game (Achtman, Green & Bavelier, 2008). For example, *Solitaire* requires the gamer to use his or her problem solving and mental imagery to anticipate where to move his or her cards to open up a new spot on the deck to lay a king. This form of gaming is unlike the other four because at no point are there any unexpected events that occur that need rapid reaction such as an enemy popping out behind a wall in an action game or a counter attack from the enemy army in a strategy game.

These four categories of videogames are at their core sedentary activities. In contrast, exergaming or interactive videogame technology mixes videogames with the ability to interact with the screen by moving one's body. Games of this genre include *Dance Dance Revolution* and some of the *Nintendo Wii* games. The motivation and main focus of exergaming is to restructure the sedentary behaviors of traditional videogames and shape them into more enjoyable physical behaviors that have a positive impact on your health. Exergaming has been examined in previous research with regard to positive effects (Best, 2010, Best, 2011, Russell, 2009), but discussion of this type of videogame is beyond the scope of this study.

Videogamer Skills

The skills of videogamers have been researched extensively. Following videogame playing, certain abilities and skills have been shown to be increased: selective attention (Green & Bavelier, 2003), attentional capacity (Green & Bavelier, 2003), tracking and scanning skills (Boot, Kramer, Simmons, Fabiani, & Gratton, 2008; Clark, Fleck, & Mitroff, 2011; Sungur &

Boduroglu, 2012; Trick, Jaspers-Fayer, & Sethi, 2005), spatial resolution (Green & Bavelier, 2007; Sungur & Boduroglu, 2012), contrast sensitivity (Li, Polat, Makous, and Bavelier 2009), reaction times (Castel, Pratt, &Drummond, 2005; Clark, Lanphear, & Riddick, 1987; Dye, Green, and Bavelier, 2009b; Fildes and Allan, 1989), spatial attention (Dye & Bavelier, 2010; Feng, Spence, & Pratt, 2007; Green & Bavelier, 2003; Green & Bavelier, 2006b), visual rotation (Feng et al., 2007), and visual short term memory (Boot et al., 2008). Researchers have focused considerable attention on visualization, concentration / selective attention, scanning and tracking since these four skill areas are necessary in sedentary videogaming (Barlett, Vowels, Shanteau, Crow, & Miller, 2009). These domains will be discussed in more detail in subsequent paragraphs.

Visualization is the ability to mentally change patterns in the visual field (Colom, Contreras, Shih, & Santacreu, 2003). A videogamer employing his or her visualization skills has to constructively form the mental image of an object and then perform a designated task. For example, gamers playing *Tetris* are required to recognize the shape falling, and form a mental image of where the shape fits into the already laid blocks to form the most efficient use of the falling block. Research on skilled *Tetris* players found that they were able to use their ability to visualize the blocks and mentally rotate the blocks better than non-Tetris players (Sims & Mayer, 2002). This suggests that games that require visualization as an essential component for effectiveness may improve this cognitive skill in these players. Alternatively it is possible that players with strong visualization skills may select to play games such as *Tetris* because they have strong visualization skills.

Concentration or selective attention refers to the ability to filter out irrelevant information while focusing on important information that is relevant to the task. This skill is essential when playing action videogames. Gamers playing a game such as *Call of Duty or Unreal Tournament* have to be able to quickly distinguish between irrelevant objects on screen (such as a wounded ally that you cannot help) and relevant information (such as an enemy shooting a grenade at the player) to make appropriate game-related decisions. Research suggests that those who play videogames are more capable of concentrating on relevant information and can either filter out irrelevant information or have a higher attentional capacity to take more things in (Green & Bavelier, 2003). Researchers have used this ability to allocate attentional resources to games as a means of dealing with pain in burn patients (Carrougher et al., 2009). They found that the patients were using most of their concentration and attentional resources to attend to the game that they could no longer attend to their pain response.

Scanning is the ability to recognize stimuli in the visual field after repeated exposure. For example, while playing *FIFA*, gamers are required to constantly scan their visual field for potential opponents attempting to steal the soccer ball and potential teammates ready to receive passes. They are also required to scan for broader situations like strategies or plays that will increase the likelihood of scoring a goal. In one research study it was demonstrated that that videogame players were able to detect changes while requiring less exposure to the change than non-videogame players (Clark et al., 2011). The authors of the study suggested that the findings may be the result of videogame players utilizing broader search patterns when scanning scenes for potential changes.

Tracking in the form of video gaming includes tracking with the use of one's hands on a keyboard or controller and attending to objects on the screen via visual tracking (Barlett, 2009). For example, when gamers play the *Call of Duty* franchise and they are using a long range weapon with a scope, they have to align the scope on the target and track their movements to accurately predict and measure where to aim. Research has shown that videogame players can track more objects and maintain identity of tracked objects better than non-videogame players (Sungur & Boduroglu, 2012).

These four domains: visualization, selective attention, scanning, and tracking do not act independently of one another which is why most research has attempted to compile them together operationally. These skills are used while playing any form of videogame and through the use of training; many researchers have shown that they can be improved in non-videogame players (Green and Bavelier (2006) and Feng et al., (2007). Other videogame research has been conducted using videogame players (VGP) and non-videogame players (NVGP) in training exercises to attempt to understand the effects videogames have on people who have not been exposed to them on a daily basis. Through these types of experiments, certain cognitive functions, including attention and vision, reaction speed, and executive control have been monitored. The next sections will discuss research on videogames and these specific cognitive functions. Research for each cognitive function will be divided into experimental (where measurement materials are designed for experimental conditions) and clinical (where measurement materials are designed for clinical purposes). These differences are separated because the ability to generalize is extensively different in an experimental condition compared to a clinical condition.

Experimental Visual Attention and Videogames

Attention and vision in videogames have frequently been examined in the research on videogaming (Boot et al., 2008; Clark et al., 2011; Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006, 2007; Sungur & Boduroglu, 2012). Researchers have focused primarily on different functions of visual attention. Visual attention is defined as the visual system's ability to use object recognition to visually select relevant parts of a visual image. For example, if an individual is playing a first-person shooter such as *Call of Duty* and he or she is looking for ammunition, he or she has to rapidly scan his or her visual field for the ammunition while still attending to other important and relevant information. Videogames today have become much more visually complex and demanding, and include unnaturally complicated visual requirements not seen in everyday life. In most videogames, multiple objects must be processed synchronously and the ability to reject the unnecessary and irrelevant objects must happen instantaneously. In the present videogame literature, certain apparatuses have been used in experiments comparing videogame and non-videogame players to measure effects of short or extended bouts of videogame playing. These apparatuses and the research relevant to each one will be discussed in the following paragraphs to highlight the ways to measure and document the differences of visual attention between videogame and non-videogame players.

The multiple object tracking paradigm (MOT) and the multiple identity tracking paradigm (MIT) tasks have been used in research to study participant's ability to process a constantly moving and changing object. The MOT task requires participants to track identical targets that are moving randomly among other identical distractors for a set time period. The MIT task is similar but instead of tracking identical targets, the participant tracks unique objects which are thought to make it more analogous to real life tracking tasks. Videogame players were found to be able to track 2 more objects in a MOT task than non-videogame players (Green & Bavelier, 2006a). Playing action videogames enhances the number of objects that can be perceived and appears to be explained by changes in visual short term memory (Green & Bavelier, 2006a; Trick, Jaspers-Fayer, & Sethi, 2005). Green and Bavelier (2006a) trained non-videogame players on action videogames and found that training increased the non-gamers ability to track multiple objects compared to the non-action game control group. The MIT task was also found to be different for videogame players and non-videogame players. Videogame players were more accurate than non-videogame players in reporting the location of the target among tracked items and were able to track more objects (Sungur & Boduroglu, 2012).

The perceptual load paradigm measures the attentional resources of videogame players and non-videogame players. It can be used to observe the differences of central and peripheral resources (Green & Bavelier, 2006b). Central resources are those that are allotted towards an individual's central vision and peripheral resources are those that are allotted to an individual's peripheral vision. Relatively easy perceptual tasks do not require all of someone's attentional resources and the left over resources are not turned off but are distributed to surrounding items or locations. In contrast, harder perceptual tasks that require more of someone's attentional resources leave fewer resources to be distributed to distractors or surrounding items or locations. Green and Bavelier (2003) hypothesized that videogame play increased the amount of available attentional resources and increased the selectivity of spatial processing. Using the perceptual load paradigm, videogame players continued to process the distractors even at the highest loads whereas non-videogame players did not, suggesting an increase in attentional capacity. These beliefs that videogamers had higher attention capacity was explained by the fact that videogame players were able to process items in their central vision and have enough attention to spill over to distractors in their peripheral vision.

They then used the useful field of view paradigm (UFOV) task to determine if videogame players have higher selective attention by being able to better filter out distractors than non-videogame players (Green & Bavelier, 2003). The (UFOV) gives a measure of the distribution and selectivity of visual attention across a wide field of view. It does this by measuring the ability to locate a target, the number of distracting elements in the display, and the presence of an added center task. This center task requires the participants to focus on completing a task in the center of their vision while still maintaining their attentional focus on their peripheral vision (Green & Bavelier, 2006b). They found that videogame experience greatly increased the ability to select targets from distractors pointing to an overall increase in selective attention in videogame players. Using this same task, Green and Bavelier (2006) and Feng et al., (2007) trained non-videogame players on action videogames and found that they were better able to identify targets in a cluttered field than those players trained on non-action games. These subjects made substantial gains in both spatial attention and visual rotation with effects seen from the training to also extend beyond the videogame training setup.

Similar to the UFOV task, crowding occurs when it is much more difficult to identify a target object when other distracting objects are present in its immediate vicinity compared to when the target object is alone. Green and Bavelier (2007) used the crowding effect to determine the spatial resolution of visual processing in videogame and non-videogame players. They measured the smallest distance a distractor could be from the target object before it hindered the participant's ability to identify the object. Videogame players could withstand smaller target distractor separation than non-videogame players leading to the conclusion that the spatial resolution of visual processing is enhanced in videogame players. In addition, similar effects were observed when Green and Bavelier (2007) trained non-videogame players.

Research using Temporal Order Judgment (TOJ) showed that action videogame players have higher levels of sensitivity to exogenous events in the visual array (West, Stevens, Pun, & Pratt 2008). Exogenous attention was defined as the efficiency with which important things in the environment can capture attention. In a Temporal Order Judgment task, an exogenous cue was used to shift spatial attention to a target location. Once attention was shifted, two target items appeared separated by a variable object distractor. Participants are then tasked with reporting which target item was perceived to have appeared first. They found that experience with action videogames influenced sensory processing, therefore increasing sensitivity to salient visual events that capture attention.

Contrast sensitivity, or the ability to detect subtle changes in stimulus contrast, is one of the building blocks for a wide range of visual functions which include attention and object recognition. Videogame players were compared to non-videogame players in a contrast sensitivity procedure that measured it at several spatial frequencies. Research found that videogame players had increased contrast sensitivity at all but the lowest spatial frequencies (Li et al., 2009). Furthermore, a group of non-videogame players took part in a 50 hour videogame training study. Those participants that played an action videogame compared to the non-action game made substantial improvements. These results suggest that action videogames improve contrast sensitivity and the visual processing associated with the action based game is the mechanism for improvement.

Understanding that videogame players have higher selective attention and attentional capacities, researchers looked to see if videogame players used different strategies than non-videogame players to obtain those higher attentional skills (Clark et al., 2011). They used a change detection task because it is a tool for exploring issues of visual attention and perception since successfully noticing a visual change across a disruption requires forming, maintaining, and comparing visual representations. These three necessary components of successful change detection tap into aspects of visual perception, attention, and memory, and each of these processes has been found to be enhanced in videogame players. They found that videogame players were able to better detect change because they used a broader search pattern than non-videogame players.

In contrast to the findings that videogame players and non-videogame players differ on certain measures of attention and vision, research conducted determined that they were similar in their exogenous attention (Dye, Green, & Bavelier, 2009a). The Attentional Network Task (ANT) is a measure of how well attention can be both allocated to a visual scene and used to filter irrelevant information with that scene. The ANT requires participants to detect the orientation of a target arrow (pointed left or right) that is presented either above or below a central fixation point. Their speed and accuracy of responses is also measured. Trials may be cued as to the timing of the presentation or the location. By comparing these two cued conditions (time and location), the ability to allocate attention at a given time and the ability to allocate attention to a given location can be measured. There was no significant difference in the way an exogenous cue changes the allocation of attention for videogame players versus non-videogame players (Dye et al., 2009a). Further research comparing videogame players and non-videogame players in their ability to inhibit attention from returning to previously attended locations was conducted (Castel et al., 2005). Evidence suggests that videogame players and non-videogame players were not different in the manner in which attention is shifted from cued to uncued locations. Videogames are full of exogenous events, such as enemies jumping out at random, grabbing your attention but playing videogames does not change the way an exogenous cue initially captures attention.

Overall, action videogames have been shown to greatly enhance several aspects of visual attention and basic building blocks of vision. Research comparing videogame and non-videogame players and training studies done on non-videogame players provided the data showing these effects (Feng et al., 2007; Green & Bavelier, 2003, 2006, 2007; Sims & Mayer, 2002; Sungur & Bodurogu, 2012; Trick et al., 2005; West et al., 2008). Comparative studies between videogame and non-videogame players focusing on exogenous attention have been inconclusive (Castel et al., 2005; Dye et al., 2009a). This is potentially related to limited requirements put on choosing a participant pool for videogame players. Videogame players can have thousands of hours and years logged playing games which can influence the additive benefits of playing such games. When focusing on videogame training studies, the ability to generalize outside of the training apparatus still needs to be more clearly researched. This will allow such training studies to be able to generalize the increased abilities gained through playing action videogames into other areas of cognition and the participant’s life. Fewer studies have examined the impact of videogame playing on clinical measures of attention.

Clinical Attention and Videogames

The current body of research on the effects videogames have on visual attention has focused strongly on apparatuses (MOT, MIT, perceptual load paradigm, UFOV, TOJ, ATN) created for purposes of measuring differences in attention in a lab. Generalizing these findings through the use of more clinical measurements of attention is the next step in understanding the different implications that videogames can have on gamers. Clinical interpretation of visual attention is different than in an experimental setting. For example, attention on such psychological tests as the *Wechsler Adult Intelligence Scale* (WAIS-IV), *Woodcock-Johnson Tests of Cognitive Abilities* (WJ-III), or the *Developmental Neuropsychological Assessment* (NEPSY-II) all measure attention differently than those used for experimental lab measurements. Not only are they measured and created for more clinical purposes, they are also tested and normed on thousands of participants so the interpretation of results are different.

In an attempt to see if a brain training game called *Brain Age* can have any impact on attention, elderly participants were grouped into one of two groups; a control group that played *Tetris* and a group that played *Brain Age* for 15 minutes per day for at least 5 days a week for a total of 4 weeks (Nouchi et al., 2012). *Brain Age* has a total of 9 different brain training games and 8 games were used. These were: Calculation X 20, Calculation X 100, Reading Aloud, Syllable Count, Low to High, Head Count, Triangle Math, and Time Lapse. To measure attention, clinical measurements from select cognitive IQ assessments were chosen: Digit Cancellation Task, Digit Span Forward, and Digit Span Backwards. Digit Cancellation Task is a subtest used to evaluate attention in which a report sheet has 12 rows of 50 digits. Each row including 5 sets of numbers from 0 to 9 compiled in random order. The participant is asked to slash through a targeted number designated at the beginning within a set time period. Digit Span Forward requires participants to remember and repeat numbers presented from the evaluator in correct order while Digit Span Backwards requires the participants to repeat these numbers in reverse order. Comparing participants from the *Tetris* control group and the *Brain Age* experimental group suggested that playing the brain training game had no significant impact on participant's attention (Nouchi et al., 2012).No other studies that examined clinical measures of attention were located in the literature. This type of research is important to understand whether the positive findings with experimental attention can be replicated with clinical measures of attention.

Experimental Reaction Time and Videogames

Reaction time is defined as the interval of time between the signal for an action and the response (Castel et al., 2005). Research suggests that videogame and non-videogame players share similar visual attention mechanisms, but by playing videogames, gamers have faster stimulus response mapping creating quicker reactions when presented with a target than non-videogaming peers (Castel et al., 2005). They hypothesized that the increase in stimulus response mappings in videogame players could have developed from the necessity to survive in hostile and rapidly changing environments when playing action videogames. It has also been suggested that videogame players had better control over their central executive processes so that when the game became more demanding, they could more efficiently control their attention and allocate it more successfully (Green & Bavelier, 2003).

Similar to other findings, there is evidence that videogame players had faster response times compared to non-videogame players (Castel, et al., 2005; Clark et al., 1987; Dye et al., 2009b; Fildes & Allan, 1989). Researchers looked at available research on response times but concentrated on accuracy measurement of videogame players to see if they were not simply trigger happy while being inaccurate (Dye et al., 2009b). This meta-analysis revealed that videogame players and non-videogame players were equally accurate but videogame players had an 11% decrease in response times relative to non-videogame players. Researchers hypothesized that a faster response time in videogame players is attained because of the demands put on the players of action videogames (Castel et al., 2005). Videogames require demanding visual searching on screen for stimuli that could be friendly or potentially dangerous which is believed to lead to videogame players being more vigilant and aroused. The arousal may activate motor responses which decreases gamer's response times.

A few studies have indicated that non-videogame players can be trained through the use of videogames to improve response times (Clark et al., 1987; Dye et al., 2009b; Green, 2008). In each of these studies, non-videogame players were separated into, a control group and an experimental group. The experimental group played an action videogame while the control group played a game just as engrossing to control for motivation biases. These training studies used pre and post-test measures that were taken days before and after the training session to attempt to exclude short-term effects of playing a videogame. Dye et al., (2009b) reported a decrease of 13% for response times in their experimental group and a 6 % in their control group.

Videogame players have been shown to produce quicker response times and stimulus response mappings (Castel et al., 2005; Clark et al., 1987; Dye et al., 2009b; Green, 2008). They are also able to more efficiently control their executive processes that allow them to adequately control their attention and visual search patterns more efficiently. Fewer studies have examined the impact of videogame playing on processing speed using clinical measures. These are important to consider because they use measures that are more capable of generalizing increases found from playing videogames to outside factors.

Clinical Processing Speed and Videogames

Research on videogames suggests that the sheer act of playing them can increase one's processing speed without sacrificing accuracy. Using videogames in a clinical setting to increase elderly or cognitively impaired individual's capabilities is a growing idea. *Brain Age,* a brain training game was used to compare elderly participants on a measure of attention. It was also used to measure processing speed between the *Tetris* control group and the *Brain Age* experimental group (Nouchi et al., (2012). This training study used two clinical measures of processing speed taken from the WAIS: Coding, and Symbol Search. Coding requires participants to look at a key that has symbols corresponding with certain numbers. This key allows them to fill in an array of numbers with the specific symbol as quickly as possible within a 120 second period of time. Symbol Search requires participants to scan two groups of symbols which include a target group and a search group. They have to indicate if either of the target symbols are included in the search group as quickly as possible within a 120 second time limit. Participants who were included in the *Brain Age* experimental group performed significantly better than the elderly participants in the *Tetris* group on the clinical measures of processing speed. Because this study was only performed on elderly individual's playing a brain training game, more research needs to be conducted using clinical measures to document the impact videogames have on processing speed in other populations.

Experimental Working Memory and Videogames

Executive controls are a set of mental processes that helps control and regulate one's abilities and behaviors (Dawson & Guare, 2010). These are high level abilities that influence more basic abilities like planning, organizing, strategizing, paying attention to and remembering details, and managing time and space. Research has been conducted on videogame and non-videogame players to determine the effects different types of games have on executive functioning. Executive control is one of the main aspects of health that deteriorates once you get older and through the use of cognitive training and videogames, this loss can be slowed, or almost reversed (Basak, Boot, Voss, & Kramer, 2008). Action videogames, strategy games, and puzzle games are the three categories of videogames most researched in this area that have an impact on executive functioning.

Of the three categories, it is easy to see how a very complex strategy game might have direct impacts on executive functioning. When playing a strategy game, skills such as memory for where enemies and resources were located, remembering the complex sequence of events required to attain multiple simultaneous goals, and being able to switch between tasks as the games demands change rapidly seem to be very important to successful play. However, action videogames have elements closely related to strategy games but in different contexts that are similar enough to increase executive functioning elements. Action videogames have already been shown to increase certain visual attention abilities and processing speed but research has been conducted to see their impacts on executive functioning. By having to remember locations and identity of objects and enemies in the environment and having to switch between various goals such as killing enemies, locating supplies, and navigating all require executive functioning for success. The use of puzzle games have focused on the genre of brain training games as the beneficial effects are expected to improve cognitive functions such as executive functioning, memory, and processing speed. Most brain training games contain tasks that require the participants to remember information, make judgments about information, comprehend texts or imagine how objects might look in different rotations.

Training studies in the area of executive functioning have focused mostly on the elderly as they may experience declines in a number of cognitive areas. A meta-analysis compiled a list of past research on the elderly and cognitive areas that declined (Basak et al, 2008). The abilities that showed the greatest decline after the age of 60 were those related to executive functioning. Thus, through the use of videogame training, researchers hoped to develop a transfer effect of skills learned through gaming to help elderly delay the declines they may experience. Training was conducted with elderly individuals to determine the effects playing a real time strategy game, Rise of Nations (RON), had on their executive functioning (Basak et al., 2008). They split volunteer participants into a training group that played RON for 23.5 hours and a control group that did not receive any videogame training. They administered cognitive tasks that measured executive control and visuospatial attention before, during, and after training on the individuals. Basak et al., (2008) found significant transfer effect to four executive control functions through training with RON: working memory, reasoning, task switching, and visual short-term memory. Working memory was measured by the N-back task in which it required participants to remember letters that appeared one at a time on a display. They then would be asked to compare letters that they saw one and two times back. Reason was measured by a modified Raven's Advanced Progressive matrices task. This required participants to look at a visual puzzle with a piece mission and find the piece that completed the pattern. Task switching was measured by requiring participants to switch between two tasks. The first required them to judge if a number (1 – 9) was either even or odd and the second task required them to determine if the number was smaller or larger than 5. Visual short-term memory was measured by having participants look at a display that had two to four different colored lines at varying orientations (tilted left or right, vertical, or horizontal). The screen would then go black for a set time period then a test display would appear. Participants had to indicate if anything on the test display was different than the original.

In an attempt to recreate past research on the impacts action videogames have on a wide range of cognitive abilities, including attention, executive control, and memory, non-videogame players and videogame players were compared (Boot et al., 2008). Non-videogame players were also given training where they played an action, puzzle, or strategy game. They found that videogame players could better detect changes to objects stored in visual short term memory, switched more quickly from one task to another and mentally rotated objects more efficiently. Unlike previous findings, using the Ravens matrices to measure reason did not show a significant difference between videogame and non-videogame players.

These results suggest that playing certain types of videogames can have a positive effect on certain aspects of executive control, at least in elderly populations (Basak et al., 2008). Playing these cognitively enriching games improves working memory, reasoning, task switching, and visual short-term memory. These findings are especially important for helping elderly participants slow the aging process and may in the future be used as a much more widely accepted form to train cognitions in the brain. The next section will attempt to cover the research using clinical measures of executive control. These are measures that have been shown in clinical settings to be able to accurately measure cognition.

Clinical Working Memory and Videogames

Videogame training studies also looked at the effects a brain training game had on elderly participant's executive functioning by playing a brain training videogame (Nouchi et al., 2012). Participants were grouped into one of two groups; a control group that played *Tetris* and a group that played *Brain Age*, a brain training game for 15 minutes per day for at least 5 days a week for a total of 4 weeks. They took measures of cognitive functioning before and after training. These measures were grouped in four different categories: attention, executive functioning, processing speed, and global cognitive status. Executive functioning was measured by the Frontal Assessment Battery at bedside and the Trail Making Test-B. Global cognitive status was measured by the Mini Mental State Examination. After videogame training using *Brain Age* was conducted, executive functioning and processing speed were improved in the elderly participants. However, attention and global cognitive status showed no transfer effect from the videogame training. More research needs to be conducted to clearly determine the benefits videogame playing has on executive control. In the present literature, only elderly individuals were tested and broader ranges of age need to be evaluated using clinical measurements.

Brain training games such as *Brain Age* and *Lumosity* are similar to the cognitive training programs *LearningRx* and *Cogmed*. They all share the belief that cognition can be improved based on principles of brain plasticity. Other research exploring the benefits of brain training or cognitive training programs have shown encouraging results in memory (Henry et al. 2006; Jaeggi, Buschkuehl, Jonides, & Shah, 2011; Smith et al. 2009), executive functioning (Uchida & Kawashima, 2008), and processing speed (Ball et al. 2002; Edwards et al. 2005). These cognitive training programs use *Brain Age* to train individuals with repeated arithmetic problems or working memory tasks. However, because brain training videogames explore different content than do action videogames, they are beyond the scope of this study.

STATEMENT OF THE PROBLEM

Videogames are rapidly growing in popularity with people from a wide range of ages enjoying them every day. According to The NPD Group in 2011, a global market research group, consumers spent $24.75 billion on videogames, hardware and accessories. Videogame users are not limited to adolescents; 68% are above the age of 18 (Siwek, 2010). In U.S. households, males account of 53 % of videogame players (Siwek, 2010).

Videogames usage is widespread and research has been conducted to determine if playing them has any positive or negative lingering effects. The main source of research directed at videogames has been on sedentary videogames. These are games that do not require physical movements aside from manipulating joysticks and buttons. Of these forms of videogames, there are certain types or genres that exist: first-person or third-person action games, sports or racing games, games that require fast visual-motor control, strategy games, and puzzle and card games. First-person or third-person action games have been studied considerably more than any other type because of the cognitive demands they place on the player. These types of games require extensive use of visual attention as players are forced to continuously monitor the screen for unexpected events that need swift and accurate aiming responses.

Using these videogames, researchers have compared videogame players with non-videogame players in comparative studies and have attempted to train non-videogame players with videogames to see if the same results are present. The major focuses of these studies have been on visual attention (Dye et al., 2009a; Feng et al., 2007; Green & Bavelier, 2003; 2006; 2007), processing speed (Castel et al., 2005; Clark et al., 1987; Dye et al., 2009b; Fildes & Allan, 1989), and executive control (Basak et al., 2008; Boot et al., 2008; Nouchi et al., 2012). The focus of these studies was on how action videogames cause drastic differences in videogame and non-videogame players.

In experimental comparative studies, researchers used apparatuses such as the MOT, MIT, perceptual load paradigm, UFOV and TOJ, to measure differences in videogame and non-videogame players (Green & Bavelier 2003, 2006, 2007; Geng et al., 2007; Sungur & Boduroglu, 2012; Trick et al., 2005; West et al., 2008). Overall, certain abilities and skills have been shown to be increased from playing videogames: selective attention (Green & Bavelier, 2003), attentional capacity (Green & Bavelier, 2003), spatial resolution (Green & Bavelier, 2007; Sungur & Boduroglu, 2012), contrast sensitivity (Li et al., 2009), reaction times (Castel et al., 2005; Clark et al., 1987; Dye et al., 2009b; Fildes and Allan, 1989), spatial attention (Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006), visual rotation (Feng et al., 2007), and visual short term memory (Boot et al., 2008) These measurements however are experimental and the belief that videogames can alter cognitive processes outside of the lab and generalize into normal living has not been thoroughly tested.

Experimental research conducted on non-videogame players while training them with videogames has suggested similar results as the comparative studies. Other present training studies used *Tetris* to train their non-videogame players because it contains a difficult visuo-motor challenge but action videogames require attention that is wide spread and not solely focused on one thing (Green & Bavelier, 2003, 2006a, 2006b, 2007; Nouchi et al., 2012). Because previous research has focused on using a more sedentary activity such as puzzle games, this study will use a different visual approach for the control group in which we use an action video that stimulates the same arousal centers in the brain as videogames without actually playing. Using clinical measurements of cognition on comparative and training studies on videogame and non-videogame players is the next needed step. This will allow researchers to more easily generalize their findings they see in videogame players to an area outside of the lab. The purpose of this study is to compare videogame players and non-videogame players before and after a short period playing a demanding action videogame on clinical measurements of attention, processing speed, and working memory.

Hypothesis 1: Previous research has demonstrated the experimental measures of attention can be influenced by playing videogames (Boot et al., 2008; Clark et al., 2011; Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006, 2007; Sungur & Boduroglu, 2012). For this reason, it is predicted that participants that are in the videogame playing group will score significantly higher on a measure of clinical attention than the non-videogame playing group.

Hypothesis 2: Previous research has demonstrated the experimental measures of processing speed can be influenced by playing videogames (Castel et al., 2005; Clark et al., 1987; Dye et al., 2009b; Fildes & Allan, 1989). For this reason, it is predicted that participants that are in the videogame playing group will score significantly higher on a measure of clinical processing speed than the non-videogame playing group.

Hypothesis 3: Previous research has demonstrated the experimental measures of working memory can be influenced by playing videogames (Basak et al., 2008; Boot et al., 2008; Nouchi et al., 2012). For this reason, it is predicted that participants that are in the videogame playing group will score significantly higher on a measure of clinical working memory than the non-videogame playing group.

METHODS

Participants

Participants included 60 college students that were male. Participants ranged in age from 18 through 24. There was not a significant difference [$t(58)$=.66, p=.51] between groups (videogame or movie group) with regard to age, and the mean age was 19.80 (SD=1.56). The majority of participants identified themselves as Caucasian (66.7%). The sample also included African American (20%) and Hispanic American (13.3%) participants. There was no difference [X^2 (2,N=60) = .43, p =.81] with regard to ethnicity between the videogame and the movie group.

Materials

Demographics form. Each participant completed a demographics from. The demographics form was used to gather information about participant's age, psychological or educational disabilities, ethnicity, and videogame experience

Wechsler Adult Intelligence Scale (WAIS-IV). The WAIS-IV is an individually administered IQ assessment by a trained professional and is a normed-referenced instrument for individuals aged 16 to 89 (Sattler & Ryan, 2009). The norm sampled for the WAIS included 2,200 adults which were stratified by sex, education level, ethnicity, and region. Internal consistency scores reported in the Technical Manual ranged from .97 to .98 for the FSIQ and from .87 to .98 for the index scores (Verbal Comprehension, Perceptual Reasoning, Working Memory, and Processing Speed).

The Processing Speed index for the WAIS is comprised of two subtests: Coding and Symbol Search and a third supplemental subtest Cancellation for addition information. These subtests give an indication of the rapidity with which an individual can process simple routine information without making errors. Coding requires participants to look at a key that has symbols corresponding to certain numbers. This key allows them to fill in an array of numbers with the specific symbol as quickly as possible within a 120 second period of time. Symbol Search requires participants to scan two groups of symbols which include a target group and a search group. They have to indicate if either of the target symbols are included in the search group as quickly as possible within a 120 second time limit. Cancellation requires individuals to scan a structured and random assortment of colored shapes and mark targets while avoiding distractors as quickly as possible. These subtests are combined to provide an overall Processing Speed index (PSI) using deviation IQ scores with a mean of 100 and a standard deviation of 15. Overall reliability coefficients for Coding, Symbol Search, and Cancellation are .86, .81, and .78 respectively.

The Working Memory Index for the WAIS-IV is comprised of two subtests: Digit Span and Letter-Number Sequencing. These subtests measure mental capacity where incoming information is temporarily stored, where calculations and transformation processing occurs, and where the products of these calculations and transformations are held. Digit Span has three components, Digit Span Forward, Backwards, and Sequencing. Digit Span Forward requires individuals to repeat increasing complex sequences of numbers, Digit Span Backwards requires individuals to reverse the sequence of those numbers, and Digit Span Sequencing requires individuals to order numbers and letters in numerical or alphabetical order after previously hearing them. The Letter-Number Sequencing subtest requires individuals recall numbers in ascending order and letters in alphabetical order after previously hearing them. These subtests are combined to provide an overall Working Memory Index (WMI) using deviation IQ scores with a mean of 100 and a standard deviation of 15. Overall reliability coefficients for Digit Span and Letter-Number Sequencing are .93 and .88 respectively.

Apparatus. One Intel based PC was used for playing *Medal of Honor* and for watching 20 minutes of *Transformers*. This computer was connected to a 22-inch monitor, Logitech wireless mouse and keyboard and seating was adjusted so that participants are approximately the same distance from the screen for each trial. Every participant was also required to wear Logitech noise canceling headphones to be completely immersed in their experience.

Stimulus. *Medal of Honor Allied Assault* (MOH) is a first-person shooter used in previous studies (Boot et al., 2008; Green & Bavelier 2003, 2006; Feng et al., 2007). It focuses on combat during World War II where players must kill enemies while staying alive themselves. Varying degrees of difficulty are achievable and every individual will play at the same difficulty level and stage in the game. Like all action videogames, MOH requires the player to attend to the screen and decipher between important information such as locating enemies at different distances and nonessential information such as location of allies.

Transformers is an action sci-fi movie which was released July 3rd 2007 and was directed by Michael Bay. It follows an ancient struggle between two Cybertronian races, the heroic Autobots and the evil Decepticons, as they come to Earth with a clue to the ultimate power held by a teenager. This particular movie is selected because it has extremely high intensity and fast paced action scenes similar to those found while playing MOH.

Procedure

The study was approved through the Institutional Review Board. Male participants were solicited through the psychology department's participant pool. The students were awarded research credit for participating in the study. Participants who agreed to participate in the study were provided with an informed consent form (See Appendix A). They were told that their participation was completely voluntary and that they could withdraw their consent at any time.

After participants completed their informed consent, they were asked to fill out the demographics questionnaire (See Appendix B). Following the questionnaire, participants were randomly assigned to either, a control group or an experimental group. Each group was pretested with the Cancellation supplemental processing speed test from the WAIS-IV to determine any specific differences between the two groups prior to the experiment. The control group watched 20 minutes from the movie *Transformers* and then tested on the measures Working Memory and Processing Speed. The experimental group played 20 minutes of *Medal of Honor Allied Assault* and then tested on the measures of Working Memory and Processing Speed. Each pretest and posttest were individually administered by a trained professional in a separate room. The 20 minutes of gaming took place in a computer lab where each game was preloaded and ready to start immediately after the administration of the demographics questionnaire and the Cancellation subtest.

RESULTS

Descriptive

Participants recorded information about their videogame behaviors outside of the study. They indicated the number of hours they participated in various types of videogames. There were no significant differences between groups (videogame and video-watchers) with regard to how much they played each of the following type of games: First-Person Shooter [X^2 (4,N=60) = 1.9, p =.75], Action/Action Sports [X^2 (5,N=60) = 5.7, p =.34], Real Time Strategy [X^2 (5,N=60) = .6.1, p =.29], Turn Based Strategy [X^2 (5,N=60) = 2.4, p =.79], RPG/Fantasy [X^2 (5,N=60) = 7.7, p =.18], or Music Games [X^2 (5,N=60) = 1.89, p =.87]. For this reason, information about self-reported videogame behavior has been collapsed across groups.

Cancellation Task. Prior to participating in the videogame or movie condition, participants were administered a measure of attention. There was no significant difference [$t(58)=.41$, $p=.68$] between groups with regard to pre-condition attention. The mean score on the cancellation task was 11.2 (*SD=1*.87). Cancellation uses norm-referenced scaled scores (M=10, SD=3) for interpretation. No participants scored below average (7 or lower), but 6 participants scored above average (14 and higher) when compared to the other individuals their age in the standardization sample.

Digit Span. Following participation in the videogame or movie condition, participants were administered a measure of working memory. There was no significant difference [$t(58)=-.05$, $p=.96$] between groups with regard to post-condition working memory. The mean score on the digit span task was 10.6 (*SD=2.37*). Digit Span uses norm-referenced scaled scores (M=10, SD=3) for interpretation. Four participants scored below average (7 or lower) and 7 participants scored above average (14 and higher) when compared to the other individuals their age in the standardization sample.

Letter-Number Sequencing. Following participation in the videogame or movie condition, participants were administered a measure of working memory. There was no significant difference [$t(58)=1$, $p=.32$] between groups with regard to post-condition working memory. The mean score on the Letter-Number Sequencing task was 10.8 (*SD=2.55*). Letter-Number Sequencing uses norm-referenced scaled scores ($M=10$, $SD=3$) for interpretation. Four participants scored below average (7 or lower) and 10 participants scored above average (14 and higher) when compared to the other individuals their age in the standardization sample.

Symbol Search. Following participation in the videogame or movie condition, participants were administered a measure of processing speed. There was no significant difference [$t(58)=.732$, $p=.47$] between groups with regard to post-condition processing speed. The mean score on the symbol search task was 10.72 (*SD=1*.93). Symbol Search uses norm-referenced scaled scores ($M=10$, $SD=3$) for interpretation. Two participants scored below average (7 or lower) and 4 participants scored above average (14 and higher) when compared to the other individuals their age in the standardization sample.

Coding. Following participation in the videogame or movie condition, participants were administered a measure of processing speed. There was no significant difference [$t(58)=-3.2$, $p=.75$] between groups with regard to post-condition processing speed. The mean score on the coding task was 10.4 (*SD=2.42*). Coding uses norm-referenced scaled scores ($M=10$, $SD=3$) for interpretation. Six participants scored below average (7 or lower) and 6 participants scored above average (14 and higher) when compared to the other individuals their age in the standardization sample.

DISCUSSION

Extensive research has been conducted on videogame players and non-videogame players through comparative and training studies to determine the extent that videogames can impact cognitive functions and attention (Boot et al., 2008; Clark et al., 2011; Dye & Bavelier, 2010; Feng et al., 2007; Green & Bavelier, 2003, 2006, 2007; Sungur & Boduroglu, 2012), processing speed (Castel et al., 2005; Clark et al., 1987; Dye et al., 2009b; Fildes & Allan, 1989), and working memory (Basak et al., 2008; Boot et al., 2008; Nouchi et al., 2012). Overall, certain abilities and skills have been shown to be increased after playing videogames. These measurements however are experimental and the belief that videogames can alter cognitive processes outside of the lab and generalize into normal living has not been thoroughly tested.

Because previous research has focused on using a more sedentary activity such as a puzzle game for their control group, this study used a different approach in which we used an action video that stimulates the same arousal centers in the brain as videogames without actually playing. To improve further on past research, clinical measurements of cognition were used instead of experimental methods in the hope that the results would more easily generalize outside of the lab.

The original goal of the study was to be able to measure processing speed, working memory, and attention from multiple instruments. Processing speed and working memory were both assessed using the *Wechsler Adult Intelligence Scale - Fourth Edition* (WAIS-IV) and attention was being measured by the WAIS-IV and the *Conners Continuous Performance Test – Second Edition (*CPT-II). However, mid-way through data collection, data from the CPT-II were lost which impacted the study greatly. There was no longer a pre-test/post-test measure of attention for comparison, and the examiners had to rely on the pretest attention measure, and Cancellation, from the WAIS-IV to look for group differences.

Results from our videogame questionnaire indicated that there was no significant difference in the amount and type of videogame male students played. After data collection, results suggested that there was no significant difference between control and experimental groups on pre and post-test measures from the WAIS-IV. This stability is what we expected knowing the reliability of each specific subtest on the WAIS-IV and we would have been disappointed if this was not the case.

LIMITATIONS

Specific limitations of our study impacted the differences seen in the pre-test and post-test measures: (1) Lack of pre-post-test measure, (2) Lack of variability between participants, (3) Lack of CPT data, and (4) experience within the game. Because we lacked a true clinical pre-post-test measure, it was difficult to accurately gauge the impact of being in the control or experimental group. To curb this limitation, we used the Cancellation subtest from the WAIS-IV to determine if the groups were initially significantly different to have an idea if the control or experimental condition had an impact. The second significant limitation was a lack of variability between the participant's scores on the WAIS-IV: Cancellation: 11.2 (*SD=1*.87), Digit Span: 10.6 (*SD=2.37*), Letter-Number Sequencing: 10.8 (*SD=2.55*), Symbol Search: 10.72 (*SD=1*.93), and Coding: 10.4 (*SD=2.42*). Each group had people scoring in the average to above average range. The third limitation was the lack of CPT data. The *Conners Continuous Performance Test – Second Edition* gives valuable data such as the ability to sustain attention for long periods of time, response speed, and accuracy. This information would have been extremely beneficial to determine if specific groups were more adept at certain aspects of attention. The last limitation was related to individuals own experience with playing *Call of Duty.* If a specific student had extensive experience already playing *Call of Duty*, it could of potentially had impacts on the amount of arousal gained from playing the game because they were already aware of what was going to happen.

DIRECTIONS FOR FUTURE RESEARCH

Using clinical measures as a test to determine the effects of prolonged and short periods of time playing videogames has the opportunity to give detailed information about how these benefits may generalize into other transient parts of people's lives. For future research, I would recommend using a clinical measure as a pre-post-test with longer periods of videogame exposure and a true control and experimental group of videogame players and non-videogame players. I also believe that we should take a deeper look at the interactions between Attention Deficit Hyperactivity Disorder (ADHD) and videogames. Videogames have the ability to sustain and capture attention for hours on end for certain individuals. Understanding and utilizing that ability to capture attention for such long durations would be extremely interesting when looking at individuals with ADHD.

REFERENCES

Achtman, R. L., Green, C. S., & Bavelier, D. (2008). Videogames as a tool to train visual skills. *Restorative Neurology and Neuroscience, 26*(4-5), 435-446.

Ball, K., Berch, D. B., Helmers, K. F., Jobe, J. B., Leveck, M. D., Marsiske, M., . . . Willis, S. L. (2002). Effects of cognitive training interventions with older adults: A randomized controlled trial. *JAMA: Journal of the American Medical Association, 288*(18), 2271.

Barlett, C. P., Vowels, C. L., Shanteau, J., Crow, J., & Miller, T. (2009). The effect of violent and non-violent computer games on cognitive performance. *Computers in Human Behavior, 25*(1), 96-102. doi: 10.1016/j.chb.2008.07.008

Basak, C., Boot, W. R., Voss, M. W., & Kramer, A. F. (2008). Can training in a real-time strategy videogame attenuate cognitive decline in older adults? *Psychology and Aging, 23*(4), 765-777.

Best, J. R. (2010). Effects of physical activity on children's executive function: Contributions of experimental research on aerobic exercise. *Developmental Review, 30*(4), 331-351.

Best, J. R. (2011). Exergaming immediately enhances children's executive function. *Developmental Psychology,* doi: 10.1037/a0026648; 10.1037/a0026648.supp (Supplemental)

Carrougher, G. J., Hoffman, H. G., Nakamura, D., Lezotte, D., Soltani, M., Leahy, L., . . . Patterson, D. R. (2009). The effect of virtual reality on pain and range of motion in adults with burn injuries. *Journal of Burn Care & Research: Official Publication of the American Burn Association*, *30*(5), 785-791.

Castel, A. D., Pratt, J., & Drummond, E. (2005). The effects of action videogame experience on the time course of inhibition of return and the efficiency of visual search. *Acta Psychologica, 119*(2), 217-230.

Clark, J. E., Lanphear, A. K., & Riddick, C. C. (1987). The effects of videogame playing on the response selection processing of elderly adults. *Journal of Gerontology*, *42*(1), 82-85.

Clark, K., Fleck, M. S., & Mitroff, S. R. (2011). Enhanced change detection performance reveals improved strategy use in avid action videogame players. *Acta Psychologica, 136*(1), 67-72.

Colom, R., Contreras, M. J., Shih, P. C., & Santacreu, J. (2003). The assessment of spatial ability with a single computerized test. *European Journal of Psychological Assessment*, *19*(2), 92-100. doi: 10.1027//1015-5759.19.2.92

Dawson, P., & Guare, R. (2010). Overview of Executive Skills. *Executive Skills in Children and Adolescents, (pp. 1-11). New York: The Guildford Press*

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

Dye, M. W. G., & Bavelier, D. (2010). Differential development of visual attention skills in school-age children. *Vision Research, 50*(4), 452-459. doi: 10.1016/j.visres.2009.10.010

Dye, M. W. G., Green, C. S., & Bavelier, D. (2009). Increasing speed of processing with action videogames. *Current Directions in Psychological Science (Wiley-Blackwell), 18*(6), 321-326. doi: 10.1111/j.1467-8721.2009.01660.x

Edwards, J. D., Wadley, V. G., Vance, D. E., Wood, K., Roenker, D. L., & Ball, K. K. (2005). The impact of speed of processing training on cognitive and everyday performance. *Aging & Mental Health, 9*(3), 262-271. doi: 10.1080/13607860412331336788

Green, C. S., & Bavelier, D. (2006). Enumeration versus multiple object tracking: The case of action videogame players. *Cognition, 101*(1), 217-245.

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

Green, C. S., & Bavelier, D. (2006). Effect of action videogames on the spatial distribution of visuospatial attention. *Journal of Experimental Psychology: Human Perception and Performance, 32*(6), 1465-1478. doi: 10.1037/0096-1523.32.6.1465

Green, C. S. (2008). *The effects of action videogame experience on perceptual decision making.* ProQuest Information & Learning). *Dissertation Abstracts International: Section B: The Sciences and Engineering, 69*(5-). (2008-99220-165).

Jaeggi, S. M., Buschkuehl, M., Jonides, J., & Shah, P. (2011). Short- and long-term benefits of cognitive training. *Proceedings of the National Academy of Sciences of the United States of America, 108*(25), 10081-10086. doi: 10.1073/pnas.1103228108

Orosy-Fildes, C., & Allan, R. W. (1989). Psychology of computer use: XII. videogame play: Human reaction time to visual stimuli. / psychologie de l' utilisation de l' ordinateur: XII. jeu video: Temps de reaction au stimuli visuels. *Perceptual & Motor Skills, 69*(1), 243-247.

Phan, M.H., Jardina, J.R., & Hoyle, W.S. (2012). Videogames: Males Prefer Violence while Females Prefer Social. *Usability News*, 14(1)

Rideout, V.J., Foehr, U.G., & Roberts, D.F. (2010). Generation M2 Media in the Lives of 8-to 18-Year-Olds. *A Kaiser Family Foundation Study*

Sattler, Jerome M., & Ryan Joseph J. Assessment with the WAIS-IV. La Mesa: Jerome M. Sattler Publisher Inc, 2009. Print.

Sims, V. K., & Mayer, R. E. (2002). Domain specificity of spatial expertise: The case of videogame players. *Applied Cognitive Psychology, 16*(1), 97-115. doi: 10.1002/acp.759

Siwek, S.E. (2010). Videogames in the 21st Century, The 2010 Report. *entertainment software association*

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

Sungur, H., & Boduroglu, A. (2012). Action videogame players form more detailed representation of objects. *Acta Psychologica*, *139*(2), 327-334. doi: 10.1016/j.actpsy.2011.12.002

Trick, L. M., Jaspers-Fayer, F., & Sethi, N. (2005). Multiple-object tracking in children: The "catch the spies" task. *Cognitive Development*, *20*(3), 373-387.

Uchida, S., & Kawashima, R. (2008). Reading and solving arithmetic problems improves cognitive functions of normal aged people: A randomized controlled study. *Age, 30*(1), 21-29. doi: 10.1007/s11357-007-9044-x

West, G. L., Stevens, S. A., Pun, C., & Pratt, J. (2008). Visuospatial experience modulates attentional capture: Evidence from action videogame players. *Journal of Vision, 8*(16), 13.1-13.9.

APPENDIX A: DEMOGRAPHIC QUESTIONNAIRE

Please read each question and answer carefully. If not applicable, write N/A.

Age in years: ________

Ethnicity: _________________

Have you ever previously been evaluated by the Woodcock-Johnson Test of Cognitive Abilities (WJ-III) or the Wechsler Adult Intelligence Scale (WAIS-IV): _______________
Date if applicable: __________
Medical Disabilities: __________________________
____

Psychological or Educational Disabilities: (Write an X next to the disability, and add further information if needed in the space allotted)

Attention-deficit/Hyperactivity: ____
Learning Disability: ____
Anxiety Disorders (panic attacks, OCD, phobias, PTSD, anxiety, etc.) **___**
Substance Use: ____
Mood Disorders (depression, bipolar, etc.**) ____**
Schizophrenia and Other Psychotic Disorders ____
Personality Disorders (antisocial, borderline, avoidant, dependent, etc.**) ___**
Other: ______________________
Further Information: ____
____
____

Videogame Playing Questionnaire – PAST YEAR

For each category of games, please rate:
1. Your EXPERTISE in that category (1 = low, 7 = high)
2. Your average HOURS/WEEK in that category for the past year.
   ex// If you play 1.5 hrs/week, mark "1+ to 3"

FIRST-PERSON SHOOTERS (Halo, Call of Duty, Gears of War, GTA, Half-Life, Unreal etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most over the past year:

____

ACTION/ACTION-SPORTS GAMES (God of War, Mario Kart, Burnout, Madden, FIFA, etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most over the past year:

____

REAL TIME STRATEGY (Warcraft, Starcraft, Command & Conquer, Age of Empires, Total War, etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most over the past year:

____

TURN-BASED STRATEGY/PUZZLE (Civilization, Sims, Puzzle Quest, Bejewled, Solitaire, etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most over the past year:

____

RPG/FANTASY (World of Warcraft, Final Fantasy, Fable, Oblivion, etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most over the past year:

____

MUSIC GAMES (Guitar Hero, Dance Dance Revolution, Rock Band, etc)

Expertise: **1 2 3 4 5 6 7** Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most over the past year:

____

OTHER (games that don't fit into any other category, phone games, browser games, etc.)

____ Hours per week: ___________

____ Hours per week: ___________

Videogame Playing Questionnaire – BEFORE THE PAST YEAR

For each category of games, please write:

1. Your average HOURS/WEEK when you played that category most
2. The games you played and how old you were when you played them most

FIRST-PERSON SHOOTERS (Halo, Call of Duty, Gears of War, GTA, Half-Life, Unreal etc)

Hours per week: <u>**Never**</u> <u>**0+ to 1**</u> <u>**1+ to 3**</u> <u>**3+ to 5**</u> <u>**5+ to 10**</u> <u>**10+**</u>

Games played most and age when played:

____

ACTION/ACTION-SPORTS GAMES (God of War, Mario Kart, Burnout, Madden, FIFA, etc)

Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most and age when played:

____

REAL TIME STRATEGY (Warcraft, Starcraft, Command & Conquer, Age of Empires, Total War, etc)

Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most and age when played:

____

TURN-BASED STRATEGY/PUZZLE (Civilization, Sims, Puzzle Quest, Bejewled, Solitaire, etc)

Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most and age when played:

____

RPG/FANTASY (World of Warcraft, Final Fantasy, Fable, Oblivion, etc)

Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most and age when played:

____

MUSIC GAMES (Guitar Hero, Dance Dance Revolution, Rock Band, etc)

Hours per week: **Never** **0+ to 1** **1+ to 3** **3+ to 5** **5+ to 10** **10+**

Games played most and age when played:

____

OTHER (games that don't fit into any other category, phone games, browser games, etc.)

____ Hours per week: ___________

____ Hours per week: ___________

APPENDIX B: INFOMED CONSENT

WESTERN CAROLINA UNIVERSITY

COLLEGE OF EDUCATION AND ALLIED PROFESSOINS

Informed Consent Form

Title of Project: **The Effects of Videogames on Clinical Measures of Attention, Processing Speed, and Working Memory**

What is the purpose of this research?

The purpose of this research is to better understand how clinical measures of attention, processing speed, and working memory can affect adolescents that play videogames frequently. This will allow clinical professionals to better understand the possible implications such habits can have on their clients, whether they be positive or negative in nature. This study is being conducted by, Russell Patton, a school psychology graduate student.

What will be expected of me?

If you are a student and you are 18 years of age or older, you are eligible to participate in this study. You will be introduced to the study then sign the informed consent form if you are willing to participate. Because participation is voluntary, you may at any time during the experiment withdraw without penalty. Then you will be instructed to fill out the demographic questionnaire and start the experiment. You will be evaluated using select subtests from the Woodcock-Johnson Test of Cognitive Abilities (WJ-III) and the Wechsler Adult Intelligence Scale (WAIS-IV) and watch a 20 minute clip of *Band of Brothers* or play 20 minutes worth of *Medal of Honor Allied Assault.* The whole process will take approximately 1 hour to complete.

How long will the research take?

Approximately 1 hour.

Will my answers be anonymous?

Yes your answers will be anonymous and confidential. The consent form is the only form that will have your name on it and we will be separated from your questionnaire and subtest scores.

Can I withdraw from the study if I decide to?

Yes, you man withdraw from this study at any time and ask that your answers may not be used.

Is there any harm that I might experience from taking part in the study?

There is no inherent risk in participating in this study. The experimenter will remain with you through the course of the experiment and will be constantly open to questions.

How will I benefit from taking part in the research?

You will be given research credit for your undergraduate psychology course. You will also have the opportunity to experience how researchers conduct experiments and your participation may ultimately inform clinicians with further information on the effects videogames have.

Who should I contact if I have questions or concerns about the research?

Contact me (Russell Patton) by email at rdpatton@wcu.edu. You can also contact my advisory Candace Boan-Lenzo at the Department of Psychology at Western Carolina University by email at cboan@wcu.edu or phone at 828-227-3369.

Please check one of the boxes below to state your preference regarding participation in this experiment.

☐ I agree to participate in this experiment.

☐ I do not agree to participate in this experiment.

By signing below, I understand what is expected of me if I participate in any part of this study and I am at least 18 years old.

Name: ____

Signature: ____ Date: ________________