

**A STUDY OF AN ADHD EXPERIENCE
VIDEO GAME'S EFFECT ON USERS' ATTENTION**

by
Jessica Balfe

A Thesis

*Submitted to the Faculty of Purdue University
In Partial Fulfillment of the Requirements for the degree of*

Master of Science



Department of Computer Graphics Technology
West Lafayette, Indiana
May 2019

THE PURDUE UNIVERSITY GRADUATE SCHOOL
STATEMENT OF COMMITTEE APPROVAL

Dr. Esteban Garcia, Chair

Department of Computer Graphics Technology

Dr. David Whittinghill

Department of Computer Graphics Technology

Dr. Paul Asunda

Department of Technology, Leadership, and Innovation

Approved by:

Dr. Colin M. Gray & Nicoletta Adamo

Head of the Graduate Program

To all that have had trouble with attention.

ACKNOWLEDGMENTS

Michael Harvey - Animator for game

Isaiah Garcia – Rigger for game

Darius Bigbee – Pre- and Post-test applications

TABLE OF CONTENTS

ABSTRACT.....	9
INTRODUCTION	10
1.1 Scope.....	10
1.2 Significance.....	11
CHAPTER 1. 1.3 Statement of Problem.....	12
1.4 Research Question	12
1.5 Assumptions.....	12
1.6 Delimitations.....	13
1.7 Limitations	14
1.8 Definitions.....	14
REVIEW OF LITERATURE	16
CHAPTER 2. 2.1 Introduction.....	16
2.2 Review of Existing Literature.....	16
2.2.1 Video Game Usage and Attention	16
2.2.2 Inattention Blindness	17
2.2.3 Measurement of Attention in Video Games	18
2.2.4 Development and Integration in Games	19
2.2.5 Frustration and Enjoyment	20
2.2.6 Benefits of Video Games.....	21
2.2.7 Media and ADHD Relationship.....	21
2.2.8 Motivation and Repetition	22
2.2.9 Medication Influence and Video Game Applications	23
2.2.10 Video Game Intervention	24
2.2.11 Video Game Engagement.....	24
2.3 Summary on Video Games & Attention.....	25
2.3.1 Serious Games' Influence on Attention	25
2.3.2 Problems with Attention	26
2.3.3 Methods of Testing Attention.....	27
2.4 Conclusions from Past Literature.....	29

	METHODOLOGY	30
	3.1 Game Intervention	30
	3.2 Typology and Framework.....	34
	3.3 Sampling Population	35
CHAPTER 3.	3.4 Sampling Approach	35
	3.5 Assessment and Variables.....	36
	3.6 Data Analysis	40
	3.7 Hypothesis.....	41
	RESULTS	42
	4.1 Attention Testing Results.....	42
CHAPTER 4.	4.1.1 Stroop Version One Results.....	42
	4.1.2 Stroop Version Two Results	43
	4.1.3 Multiple Object Tracking Results.....	45
	4.2 Attention Testing Analysis	46
	4.3 Evaluation Results	47
	4.3.1 Participant Comments.....	48
	4.4 Evaluation Analysis	48
CHAPTER 5.	DISCUSSION	50
	5.1 Summary	50
	5.2 Conclusions.....	50
	5.3 Limitations	51
	5.4 Recommendations for Future Research	52
	APPENDIX A. TABLE OF LITERATURE	53
	APPENDIX B. TESTING MATERIALS.....	56
	REFERENCES	57

LIST OF TABLES

Table 4.1 Stroop V1 statistics	43
Table 4.2 Stroop V2 Statistics	44
Table 4.3 Multiple Object Tracking Statistics	46

LIST OF FIGURES

Figure 2.1 Stages of Game Development (Bul et al., 2015)	20
Figure 2.2 Stroop Color Word Test (Clanton, 2013)	28
Figure 2.3 Multiple Object Tracking Test (Howe & Holcombe, 2012)	29
Figure 3.1 “The Inattentive Mind” – Main Screen	31
Figure 3.2 “The Inattentive Mind” – Tutorial Level Image 1	32
Figure 3.3 “The Inattentive Mind” – Tutorial Level Image 2	32
Figure 3.4 “The Inattentive Mind” – Classroom Level Image 1	32
Figure 3.5 “The Inattentive Mind” – Classroom Level Image 2	33
Figure 3.6 “The Inattentive Mind” – Classroom Level Image 3	33
Figure 3.7 “The Inattentive Mind” – Classroom Level Image 4	33
Figure 3.8 Stroop Version One Example 1	36
Figure 3.9 Stroop Version One Example 2	37
Figure 3.10 Stroop Version Two – Example of first paragraph	37
Figure 3.11 Stroop Version Two – Example of second paragraph	37
Figure 3.12 Multiple Object Tracking Test	38
Figure 3.13 Multiple Object Tracking Test.	39
Figure 3.14 Evaluation Form	40
Figure 4.1 Stroop V1 P-Value Graph	43
Figure 4.2 Stroop V2 P-Value Graph	45
Figure 4.3 MOT P-Value Graph	46
Figure 4.4 Evaluation Responses	48

ABSTRACT

Author: Balfe, Jessica, R. MS

Institution: Purdue University

Degree Received: May 2019

Title: Thesis A Study of an ADHD Experience Video Game's Effect on Users' Attention

Committee Chair: Dr. Esteban Garcia

Although some literature suggests that video games improve attention skills within the game-play, this study addressed translating this effect on attention in the real world. Research has shown video games can help people focus. Yet, there is lack of evidence displaying whether video games improve or diminish attention skills. The video game "The Inattentive Mind", a game created for this study, used a method of overstimulation in the form of user interfaces, sound, and environmental interaction to try and help participants to empathize or improve their attention skills outside of the game. Using an experimental design of pre-test, video game intervention, and post-test, results were expected to show improved attention skills. These results did not show conclusive evidence of significant changes in attention skills. However, the results did show an increase in ADHD understanding.

INTRODUCTION

I have had to cope with ADHD my entire life. Growing up I was always easily distracted. Only as I have gotten older have I learned ways to prevent myself from losing focus.

When I was younger, one of the few tasks I could do without losing focus was playing video games. I could block out the outside world and focus. When I was in the third grade my teacher told my parents to accept that I was a C grade student and that that was the best I would ever be. However, my parents knew otherwise because they would find me playing sixth grade math and science video games with ease. Video games had given me a place where I was able to show my brilliance. My own experience with video games has motivated me to create a game with the intention of giving other people the tools to improve their own attention span.

I have been greatly impacted by ADHD. Dealing with inattention problems has caused me to learn new ways to adapt and interact with stimuli. As I have learned to create video games, I found myself wanting to contribute my experiences in the form of a video game. I hoped to design a video game that could improve attention outside of game-play and increase awareness of the ADHD experience. With my video game and research study, I wanted to help people understand the struggles that many individuals with ADHD face every day.

1.1 Scope

The scope of my research was to make a game that mimics my Attention Deficit Hyperactive Disorder (ADHD) experience and that could be used to help increase attention of individuals. This process was displayed in a first-person-perspective based on my experiences, to give an immersive feeling. My game encompassed the problems of inattention and hoped to stimulate skills for improving attention.

My project covered the fields of ADHD treatments, game-based learning, and attention building. I used tools and techniques from each of these fields to encompass an experience that can best demonstrate and build an understanding of inattention. I included tools from ADHD treatments such as testing methods for attention and techniques for building attention. I worked to implement game-based learning into my study by using the characteristics which go into an educational game and the variables that can affect them.

1.2 Significance

Ineffective attention skills can lead to problems with work, learning, and daily interactions. Poor attention skills can prevent individuals from achieving their full potential in school and their careers. This is a problem that is often found in individuals with ADHD, including myself, as inattention is one of the three main symptoms of the disorder (inattention, hyperactivity, and impulsivity) and approximately “5.4 million children have a current diagnosis of ADHD [nationally]”, as stated by the 2016 National Survey of Children’s Health (CHADD, 2018). If this large population with ADHD were given the right skills, they could overcome distractions and improve the efficiency and quality of their work.

Some tools out there have already been shown to improve attention, including video games. However, many video games that have shown to increase attention, do so in a nature not related to learning or working, but rather entertainment. If this potential was taken advantage of, a game could be produced that might improve learning and working attention skills. Additionally, a game of this format could be used to help people, without inattention problems, comprehend difficulties that individuals with poor attention skills face.

There is potential for a game like this to help not just students with ADHD, but educators, parents, and employers. Games like this could become best practice to better understand those with

disabilities and allow for less discriminations as individuals who are faced with learning disabilities are not handicapped; they are capable just like those without disabilities.

1.3 Statement of Problem

One of the hardest challenges people with ADHD cope with is inattention. Being able to focus and get work done in a timely manner is difficult for students that are easily distracted. With a poor attention span, both work and learning suffer. That is why it is important for those with ADHD to train their attention spans.

Video games have shown to engage the attention of those with ADHD. Prior studies demonstrated that video games provide a dopamine surge of a sufficient amount to stimulate the ADHD mind (Dunckley, 2014). The dopamine surge allows for a greater retention and intake of knowledge. Therefore, video games could allow for more learning and be used to improve problems with attention that people with ADHD suffer from and experience.

1.4 Research Question

1. How could the video game “The Inattentive Mind”, that exposes people to a specific ADHD experience, affect a participant’s attention?
2. How could the video game “The Inattentive Mind”, that exposes people to a specific ADHD experience, affect a participant’s understanding of inattention?

1.5 Assumptions

Within this study, I made assumptions about the participants. I assumed that my sampling population would include participants that found the game mechanics challenging to work with as well as those who found them simple to work with. I anticipated having participants from different

skill levels of educational subjects, and that this would lead to some gameplay being completed more efficiently than others. Other assumptions that were made include having an adequate number of volunteers for testing. I anticipated the sample size of participants to be large enough that the results would be normalized to prevent a skew or scattering in data.

The assumptions I made about my game included it being well designed and fully functional for testing. This assumption involved not having glitches or game-breaking bugs. I also assumed the games storyline would be understandable and easy to follow for participants. Additionally, I assumed participants would understand their tasks during the game after completing the tutorial.

1.6 Delimitations

Exclusion factors for my study included computer abilities, medications, and disabilities that participants may have had. Participants that were unable to use computer software without assistance were not allowed to participate in the study. None of the individuals tested were on medication for attention. Individuals carrying the diagnosis of Autism Spectrum Disorder (ASD) were excluded from this study. Circumstances that these individuals may have faced in the study would have required more testing to alleviate confounding variables (such as dosages of medication making attention levels inconsistent, or additional assistance causing unwanted distractions for participants).

Additional delimitations included education levels, English proficiency, and location of individuals. Individuals that did not have at least a fourth-grade level of education were omitted for the study due to educational skills needed to complete the game. Participants had to be proficient in English to participate in the study. Additionally, the study only sampled volunteers from the West Lafayette and Lafayette community. The maximum sampling population for the study was 40 participants.

1.7 Limitations

Limitations of my study included sampling factors and population demographics. The population in this study included participants from various gender identities and ethnicities. All participants that volunteered were over the age of 18. Additionally, all levels of video gamers and non-video gamers were included. Participants of different attentions skill levels were selected for the study. The people that participated in the study were sampled from those who volunteered.

1.8 Definitions

ADHD – Attention Deficit Hyperactive Disorder – “a brain disorder marked by an ongoing pattern of inattention and/or hyperactivity-impulsivity that interferes with functioning or development” (National Institute of Mental Health, 2016).

Game-based Learning – "A type of gameplay that has defined learning outcomes. Generally, game-based learning is designed to balance subject matter with gameplay and the ability of the player to retain and apply said subject matter to the real world" (Team, 2013).

Inattention – When a subject “wanders off task, lacks persistence, has difficulty sustaining focus, and is disorganized; and these problems are not due to defiance or lack of comprehension” (National Institute of Mental Health, 2016).

Inattention Blindness – "The Failure to notice stimuli in the visual field, during a task requiring visual attention, that are obvious to outside observers of the task" (Simons & Chabris, 1999).

Interactive Narrative - "A form of digital interactive experience in which users create or influence a dramatic storyline through their actions" (Riedl & Bulitko, 2013).

Serious Game – "A game designed for a primary purpose other than pure entertainment" (Leng & Sharrock, 2012). In the context of this thesis these games are video games with the primary purpose to assist in attention building skills.

Story-based Simulation – A method of telling a story where a player is placed in a virtual world in which they can interact with different actions in the progression of an unfolding story (Luo, Cai, Zhou, Lees, & Yin, 2015).

User Interface – "Everything designed into an information device with which a person may interact" (Rouse, 2005). This can include display screens, keyboards, mice, controllers, menus, and the appearance of a screen.

Video Game – A game that is played using a computer, mobile device, internet browser, virtual reality system, augmented reality system, or console (Dictionary.com, 2018).

REVIEW OF LITERATURE

2.1 Introduction

CHAPTER 2
 Inattention is an issue that many individuals face. Learning how to overcome the challenges of inattention can be a struggle without the right tools. Luckily, more technology is being developed that can help improve attention. One significant tool being video games, which has the potential to improve attention skills when used properly.

When investigating how video games are useful in attention building skills, it is important to examine an assortment of publication areas. These include a variety of TED Talks, peer reviewed journals, and magazine articles that share the potential benefits of using this technology.

2.2 Review of Existing Literature

My research analyzed why these publications were relevant to the topics of attention, video games, ADHD interventions and serious games. These topics cover subjects such as digital technology use and attention, inattention blindness, testing video games, testing attention, and effects of attention medication. The subject matter of these works can be gathered to understand how a video game may affect attention. The subsections of 2.2 discussed the details of various publications that were used as the foundation of the game intervention “The Inattentive Mind.” These publications were expanded on in section 2.3 to formulate the building blocks of the game design pipeline and methodology for testing this intervention.

2.2.1 Video Game Usage and Attention

Concerning video game usage and attention, Alhadi et al. (2017) addressed the issues faced by individuals with attention problems (ADHD) when using computer tablets (Alhadi et al., 2017).

Their study showed that children who use computer tablets more than average, had an increased chance of ADHD. Additionally, the study addressed how the exact cause of ADHD (attention problems) is unknown at the current time. However, increased exposure to computer tablets, T.V., and video games is associated with an increased risk of ADHD (Alhadi et al., 2017). The data provided in this article, contained evidence that individuals with ADHD may find video games, and immersive technology to be more engaging than other media, and thus gravitate towards them. Based on this evidence, creating video games to improve attention could benefit individuals that have been diagnosed with ADHD.

2.2.2 Inattention Blindness

Inattention blindness can impact the gameplay of video games and should be considered during the design process. As discussed by Vallett, Lamb, and Annetta (2013), and Barbieri et al. (2017), inattention blindness can cause individuals to fail to notice anything outside of their game (Barbieri et al., 2017; Vallett, Lamb, & Annetta, 2013). Though the individuals may not notice the stimuli outside of their task, the said stimuli are obvious to an outside observer (Barbieri et al., 2017; Vallett et al., 2013). When this inattention blindness happens, individuals run the risk of injury, loss of important knowledge, or loss of an experience. Barbieri described how individuals' inattention while playing games like Pokémon Go have led to individuals stepping into traffic (Barbieri et al., 2017). While Vallett et al. discussed how individuals have been so focused that they have failed to notice a gorilla walking through a group of people (Vallett et al., 2013). When building a game focused on attention, recognizing how individuals experience inattention blindness helps determine a potential number of stimuli which would eliminate inattention blindness. Also, when designing an attention game, measures should be taken to make sure people, who experience inattention blindness more often, don't miss out on key points of the game.

2.2.3 Measurement of Attention in Video Games

Daphne Bavelier stated, in her 2012 TED talk, individuals who are uneducated about video games perceive that “games lead to attention problems and greater distractibility.” People want to lump all video games together; however, as shared by Bavelier, some of her research had shown improved attention and perception skills after playing hours of video games. The data gathered from these tests provided evidence that action games influenced the individuals’ abilities to switch from stimuli to stimuli quicker and perceive a greater range of the color gray. The improvement was still present five weeks after the test. Individuals in the testing were able to focus on six to seven objects in a field of vision compared to the average young adult being able to focus on three to four objects (Bavelier, 2012).

The testing procedures Bavelier and her team used were similar to intervention testing procedures. Their procedure was a pre-test, ten hours of playing the test game over a two-week period, and a post-test. The pre- and post-tests were both conducted using two variations of the same Mental Rotation test, a test measuring an individual’s ability to rotate an object in their mind correctly. In addition to the mental rotation test, Bavelier shared tests that measure attention skills, the Stroop Color Word test and the Multiple Object Tracking test (Bavelier, 2012). The Stroop Color Word test measures the speed at which an individual can state the color of a word and the accuracy of stating the correct color. The Multiple Object Tracking test measures the speed and accuracy in which participants identify the initial objects after they have moved around on a screen, with objects of the same shape and color.

The evidence from this research supports the use of similar testing procedures and measurement tests when conducting research on a video game focused around attention. Additionally, using a similar design component, such as high rate of stimuli given, can be helpful for getting similar results.

2.2.4 Development and Integration in Games

An underlying concern when making a game to achieve a change in an individual's life is the learned skills being adapted to the real world. The study by Bul et al. (2015), discussed this concern in their research. When developing their serious game for testing, they viewed the Self-Regulation Model, Social Cognitive Theory, and the Learning Theory to better regulate development. Their Self-Regulation Model views “how individuals direct and monitor their activities, and emotions in order to attain their goals” (Bul et al., 2015). They stated that the Learning Theory identifies “the general idea that individuals learn behavior through consequences and positive reinforcement” (Bul et al., 2015). The Social Cognitive Theory identified that “children's learning is influenced by interactions among the environment, personal factors, and behaviors,” (Bul et al., 2015). With these theories and models in mind, development of a serious game is impacted in terms of user interface structure, environmental, and game design. Other important points made by Bul et al. included the need for effective engagement, integrating behavior changes in games, and that the game approach helps to balance motivations and learning, while providing challenges (challenges may include solving puzzles, or battling a foe). Along with developmental regulations, Bul et al., discussed their design process for building serious games, as seen in their graphic in figure 2.1 provided below (Bul et al., 2015). Bul et al. development model is used to help create a similar model for the development of this study's game. That model referred to their practices of usability tests (in the form of questionnaires), and the pre-test, intervention, and post-test method of testing participants.

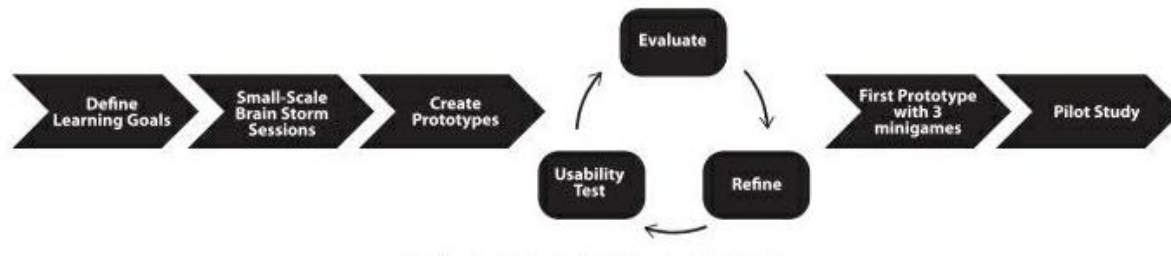


Figure 2.1 Stages of Game Development (Bul et al., 2015)

2.2.5 Frustration and Enjoyment

Frustration of interfaces can lead to game failure. Games need to be enjoyable for the player or they won't continue playing the game. In the study by de la Guía, Lozano, & Penichet (2015), this topic was discussed along with the methods of testing a unique game interface. They explained their game system (StiCap System), in which a tangible user interface, and a radio frequency identification reader are used to stimulate cognitive abilities. When testing their system, they followed the standard procedure used for intervention testing of pre-test, test, and post-test, in addition they recorded the whole session. Their pre-test asked question to obtain a participant's profile. The test phase consisted of playing three games on the StiCap System and 30 minutes later playing those games on a tablet. The post-test consisted of asking participants about their experience of playing the game on the two different systems. When assessing the performance of the participants, accuracy and time spent with the system was recorded. The participants were also measured on their performance of cognitive abilities, such as memory and attention. Throughout testing individuals were also questioned over their motivation and interest in the games. The study resulted in participants expressing more interest and motivation towards the game after completion. The article stated that avoiding frustration was one of the biggest challenges when implementing this design. With their unique system, they had the ability of placing their interactive device in the user's hand; however, this device presented the possibility of lag between the controllers and the

system, which could lead to frustration. Their results demonstrated how people learn best through play, especially if they enjoy what they are doing. However, their results showed that when frustration overtakes the interaction, individuals tend to stop learning or stop the interaction altogether (de la Guía, Lozano, & Penichet, 2015). When creating a game, it is important to reflect on this understanding of frustration they shared in their study. Additionally, it is important to view how the enjoyment of the game is affecting the participants. If a game is overly frustrating or not enjoyable a participant is more likely to stop playing that game and move on to another stimulus. When this happens, participants lose out on the opportunity the game might have offered.

2.2.6 Benefits of Video Games

Many inaccuracies are spread about the topic of video games. Most portray video games in a bad light, with a history of games mismatched to experimental research, the lack of pre-testing participants, unstandardized measures, and failure in controlling 3rd party variables (Ferguson, 2015). When games are used in addictive ways, individuals may experience disinhibition, or inattention (Metcalf & Pammer, 2014). However, as discussed by Ferrara (2013), Metcalf and Pammer (2014), and Ferguson (2015), video games are misrepresented and can be beneficial when used properly (Metcalf & Pammer, 2014; Ferguson, 2015; Ferrara, 2013). There have been studies to show that gamers experience less violence, mental illness symptoms, and attention deficit symptoms (Ferguson, 2015). Conversely, games have beneficial effects for users and developers, with the potential for a user experience designer to contribute by finding new ways of solving problems (Ferrara, 2013).

2.2.7 Media and ADHD Relationship

Fast paced media, such as video games, have a positive relationship on ADHD and inattention behaviors in children. The article by Nikkelen, Valkenburg, Huizinga, and Bushman

(2014), discussed their hypothesis for the relationship between ADHD and fast paced media, through the Scan-and-Shift Hypothesis, and the Fast-Pace-Arousal-Habituation Hypothesis. The Scan-and-Shift Hypothesis, states that “many cuts and edits [teach] kids an attentional style of scanning and shifting,” this hinders individuals’ ability to sustain attention. The Fast-Pace-Arousal-Habituation Hypothesis addresses that fast-paced media can cause an "increase arousal by triggering repeated attention shift in a user," this method also hinders individuals due to the quick movement of their attention. Nikkelen et al. also discussed the influences that media content (violent, fast paced, etc.), media types (T.V., movies, video games), and characteristics of a child (age, gender) could affect the strength of the relationship between fast-paced media and arousal. From the results of Nikkelen et al.’s meta-analysis, they demonstrate how developers of a serious game must be aware that quick cuts, and overstimulation can cause a decrease, rather than an increase, in attention skills (Nikkelen, Valkenburg, Huizinga, & Bushman, 2014).

2.2.8 Motivation and Repetition

Motivation is the driving force that compels individuals to learn and participate. Rego, Rocha, Faria, Reis, and Moreira (2017) described that the best retention occurs when participants are motivated, and the lessons taught are repetitive. They explained that lack of motivation causes a lack of interest, and that competition, collaboration, and handicapping are some methods of instilling motivation within games. The use of competition or collaboration motivates individuals through the means of communication and interaction with another person. The use of handicapping allows individuals to try a task they could have already completed as though it was for the first time again. Additionally, Rego et al. defined that learning “effectiveness is bigger when patients follow intensive training programs, oriented to reach a goal and divided into specific tasks that have to be performed repetitively,” (Rego, Rocha, Faria, Reis, & Moreira, 2017). The breakdown of a

learning objective allows individuals to focus on parts of the whole to slowly build up to an understanding of the big picture of the objective. Rego et al. conducted a study for training cognitive rehabilitation using a multimodal interaction method that incorporated competition, collaboration, and socialization. “Multimodal is the combination of multiple modalities,” in this case, the receiving of inputs and outputs to the system, through mouse clicks and voice command (Rego et al. 2017). The study addressed how competitive and collaborative interactions are able to help give a more fluid form of repetition and motivation in addition to the game's mechanics.

2.2.9 Medication Influence and Video Game Applications

The review of literature article by Strahler Rivero, Herrera Nuñez, Uehara Pires, & Amodeo Bueno (2015), described the influence of attention medication on a study concerning the uses for video games within schools and learning environments. The research concluded that medications can be a confounding variable within testing procedures. This article discussed when the participants being tested are taking medication, consideration must be addressed for the type and dosage of a medicine. Furthermore, participants would need to be stratified into groups to understand how the medication may have altered results (Strahler Rivero, Herrera Nuñez, Uehara Pires, & Amodeo Bueno, 2015).

Their literature discussed how video games could promote cognitive performances, improve attention, enhance motivation, and inhibit control within ADHD participants (Strahler Rivero et al., 2015). The games use training and drilling practices to simulate learning, similar to test taking in the classroom. The video game applications they researched presented an ability for instructors to spend more time building the lessons, and less time on repetitive testing or assignments. These games exhibit heightened activation and arousal states within players (Strahler Rivero et al., 2015).

2.2.10 Video Game Intervention

A participant's attention level increases or decreases the effect serious games have on their learning. Weerdmeester, Cima, Granic, Hashemian, & Gotsis (2016), performed a study over a full body game and a control test to measure participant's feasibility and effectiveness of decreasing ADHD symptoms. The full body game consisted of participants embodying a dragon through the use of the Xbox Kinect and have him save his world. The control test consisted of playing a Kinect version of "Angry Birds Trilogy" in which players used their arm to create catapult trajectories for the birds. They found when they engaged their audiences' attention with a full-body video game, results were more effective than the control test. The game had effectively targeted the impulsivity of participants (Weerdmeester, Cima, Granic, Hashemian, & Gotsis, 2016). However, they also found that the repetitive tasks caused a decrease in attention, due to monotony. Their finding helped to balance an understanding that more involvement with less repetition will help to regulate a participant's attention and learning.

2.2.11 Video Game Engagement

Video games engage players using pleasure and likability. In his 2010 TED talk, Tom Chatfield, discussed how video games address these states of mind in seven ways. Games use the following aspects "experience bars, multi long- and short-term aims, rewards for effort, rapid frequent clear feedback, an element of uncertainty, windows of enhanced attention, and other people" to engage players (Chatfield, 2010). Using these characteristics, games can build a foundation for an experience that could offer a variety of engagement approaches and gameplay diversity. These techniques could result in a game which attracts a multitude of people. Chatfield (2010) also discussed how video games are adjusted to reward effort and have calculated

randomness to keep gamers interested while not feeling defeated by the game (Chatfield, 2010). In conclusion, it is important to realize how games can engage an audience. Furthermore, incorporating versions of these game methods will give players more desire to play the game.

2.3 Summary on Video Games & Attention

After completing the research, I understood that it is important to categorize and analyze these works together for a more complete understanding of how these publications impacted my study. I found these past works to be most beneficial when presented in the topics of serious games' influence on attention, problems with attention, and methods of testing attention.

2.3.1 Serious Games' Influence on Attention

Video games are unique tools that can heavily affect different aspects of the brain. With the engaging nature of games being able to stimulate dopamine releases, there is potential for influencing attention and interactions (Dunckley, 2014). Video games grant the potential for training and practicing skills that can be beneficial to everyday uses. However, while these games allow for the potential of positive influence, there are possibilities of negative influence, if practices are used in excessive quantities.

As discussed by Weerdmeester et al. (2016), repetition in video games is a great way to stimulate learning and allow for students with ADHD to increase attention skills; however, there is a threshold in which students' attention skills will start to decrease (Weerdmeester et al., 2016). The threshold for drilling training skills and even consistence of gameplay has been shown to cause users of serious games to decrease their performance or stop playing altogether. This factor of a threshold that needs to be met, but not crossed is a common thread in successes or failures in serious games interventions.

The importance of viewing how a game can help advance skills, and not push past the point of redundancy, allows for enjoyment and greater results. Serious game makers need to consider the diminishing returns of repetition in their game designs. With too much emphasis on one issue players can become lethargic within play and learning. In similar terms, when looking to produce a fast-paced game for attention, building a game paced too fast can lead to players becoming lost. When making a fast-paced game, designers must think how to ease a player into the games higher speed and not start too fast, too soon. Players need to feel a sense of enjoyment within the game to have a possible effect on attention.

2.3.2 Problems with Attention

In addition to addressing the influence of serious games on attention, it is important to view the problems faced with inattention and intervention on attention. Attention is a constant trait that can be affected by several variables. When a person is paying attention, they are focused. When that individual focuses issues of inattention blindness can occur. Inattention blindness is the process of overlooking an obvious stimulus because an individual is distracted by another stimulus (Vallett et al., 2013). When creating serious games to improve attention skills, awareness of inattention blindness needs to be factored into the design process. If the game tries to stimulate too much within the users' environment, the individuals can become overwhelmed. This can cause them to lose focus of important information. An example of this happening in games is well depicted by Pokémon Go as stated earlier (Barbieri et al., 2017).

When researching attention, it is important to not overlook the application of medication and mental health. The nature of attention problems gives issue to potential inconsistencies when testing, because medication may influence individuals' abilities to focus. Medication can provide the brain with the increased hormone levels (norepinephrine and dopamine) it desires for proper

focus (Childress & Sallee, 2013). To keep continuity, researchers must stipulate a requirement for either having a research pool that takes a medication or does not. In addition to medication, mental health must be viewed when testing. When an individual is in a more lethargic state compared to a favorable state attention will be harder to maintain. In turn, this will cause the results to become skewed.

2.3.3 Methods of Testing Attention

The basis of attempting to improve or change a behavior within an individual requires a different approach to testing than an independent measure study. One of the more common methods used for testing a change in behavior consists of a control group and an experimental group. The reason for this is that a baseline measure of a control group is needed to eliminate the Hawthorne effect. In the instance of testing attention, the Hawthorne effect would result from individuals thinking more about their attention, which in short could cause the participants to improve or diminish the results themselves without the assistance of the procedure. Due to this effect, researchers have used a testing method of control and experimental groups with pre- and post-testing. The control groups receiving only pre- and post-testing allows for a baseline of attention skills to compare to the experimental group. The experimental group receives the pre-test, followed by a determined procedure of intervention, and a post-test.

“We can think of attention as the ‘front end’ of cognition, the first step in the selection of the dimension(s) to which we will devote our processing,” (Macleod, C. M., & Macdonald, P. A., 2000). In other words, the defining attribute of how we are to observe the world around and focus on its different aspects. We need to address the testing of attention differently from the testing of a level of mathematical skills. When testing attention, researchers have found that the best ways to test and calculate a standardized variable is to view accuracy and speed when performing tasks

that challenge the brain's instincts. As discussed by Daphne Bavelier in "Your Brain on Video Games" the Stroop Color Word Test and the Multiple Object Track Test are methods of testing for inattention (Bavelier, 2012).

The Stroop test is used commonly to gather "an index of attentional deficits," (Macleod, C. M., & Macdonald, P. A., 2000). This test measures the brains ability to focus its attention and state a color of a word while that word is a different color-word. The outcomes of this test measure how attention is affected and its shortfalls that arise. Within the Stroop Color Word Test, individuals are assessed on how fast they react to the color of a word and list that color off accurately. An example of this test is shown in figure 2.2 below.

The Multiple Object Tracking test involves the usage of visual attention. This test measures a participants' ability to track objects while being presented with distractor objects (Tran, A., & Hoffman, J. 2013). Within the Multiple Object Tracking Test, the participants are assessed on how accurately they identify a randomly selected object's original color after all the objects move around on a screen. An example of this test is shown in figure 2.3 below.

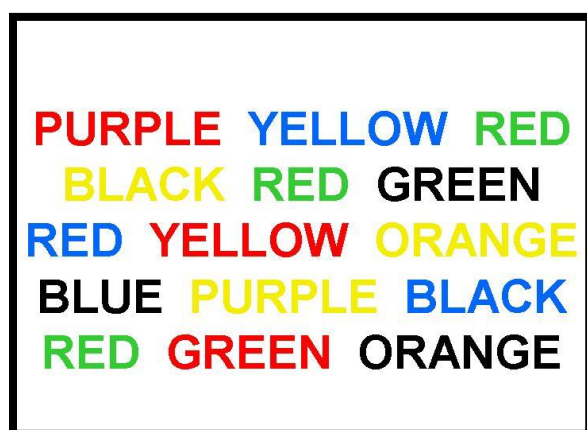


Figure 2.2 Stroop Color Word Test (Clanton, 2013)

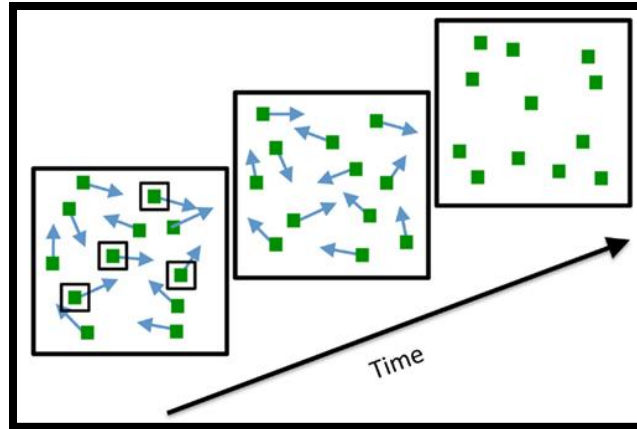


Figure 2.3 Multiple Object Tracking Test (Howe & Holcombe, 2012)

2.4 Conclusions from Past Literature

Attention problems can cause many difficulties with work and learning. Employees and students that are observed having trouble focusing on the task at hand are often generalized as unreliable or underachieving. However, these individuals may not be unreliable or underachieving, but just struggling to keep up with changing stimuli. With the right tools these people can surpass stereotypes and improve their skills.

Video games have shown the ability to improve attention in gameplay. With the correct foundation of enjoyment and high stimulation but not overstimulation, a game can be created to help those with inattention. Testing a game formed around attention also requires control groups, and pre- and post-test to prove its usefulness. The literature review provides the principles that can help to develop a game with the intention of improving attention. Moreover, these principles can be used to test the effectiveness of a serious game, in challenging and training skills for improving attention performance.

METHODOLOGY

3.1 Game Intervention

My game, **CHAPTER 3** “The Inattentive Mind”, is a first-person simulation story game. This game was created using Unreal Engine 4.18, Autodesk Maya 2018 and Krita. I used 2-Dimensional and 3-Dimensional art in the creation of this game. The design of the game stemmed from the feeling of disconnect that I have experienced when in an overstimulated environment. The game art style was centered around a 1990’s -2000’s feel, with the characters being humanoids with T.V. heads. The setting of the game was a fourth-fifth grade class day because this time was an influential one in my experience with ADHD.

The game walks through a day in a fourth-grade class starting from the moment you wake up to the time when you leave school. The game tells this story through two levels. The first level being the tutorial level opens as you wake up to your alarm. This level walks you through the controls of the game and the introduction to the story. The game then automatically transfers the player to the second level, the classroom level, where they are seated at a desk and simulate a day of examinations. The game returns players to the main menu screen after the school day is finished.

Art was used to represent the mind with 2-D user interfaces (UI) and the bedroom and classroom with 3-D models. The use of the T.V. headed figures allowed for the interruption of the 2-D UI being the inside of the T.V. screen. This imagery demonstrated the internal struggle of having to compartmentalize distracting stimuli while performing a task. The 3-D world played into this struggle with the game mechanic of looking around the environments causing 2-D UI to appear and sound to play. In addition to the internal struggle, players were to experience a feeling of disconnect between the two arts. This feeling was caused by the control of having to hold the shift key down to change from interacting with the 2-D UI or the 3-D environments.

The 2-D UI represented different possible distracting stimuli that could interfere with a student's ability to take a test. Examples of these stimuli included a flickering light, the alarm clock going off, students passing notes, and a person sleeping in class. When triggered the stimuli would pop-up on the screen overtaking the examination the player was taking. The stimuli had to then be resolved before the player could move on with their exam. This mechanic helped to simulate the feeling I have experienced when distracted from a task at hand. Furthermore, I added the reference of just trying to block a stimulus out and causing it to still distract me. This was implemented with an ignore option that would send players in an endless loop until they resolved the matter another way.

Images of “The Inattentive Mind” gameplay can be seen in figure 3.8 – 3.14. These images show how the 2-D and 3-D art came together in this game. For more reference to the game and how its mechanics worked see this [video](https://youtu.be/svNlvc-11hk). Link: <https://youtu.be/svNlvc-11hk>



Figure 3.1 “The Inattentive Mind” – Main Screen



Figure 3.2 “The Inattentive Mind” – Tutorial Level Image 1

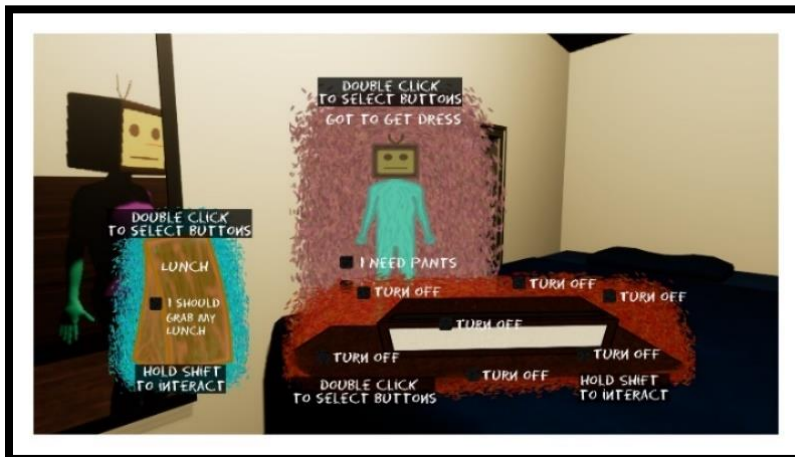


Figure 3.3 “The Inattentive Mind” – Tutorial Level Image 2

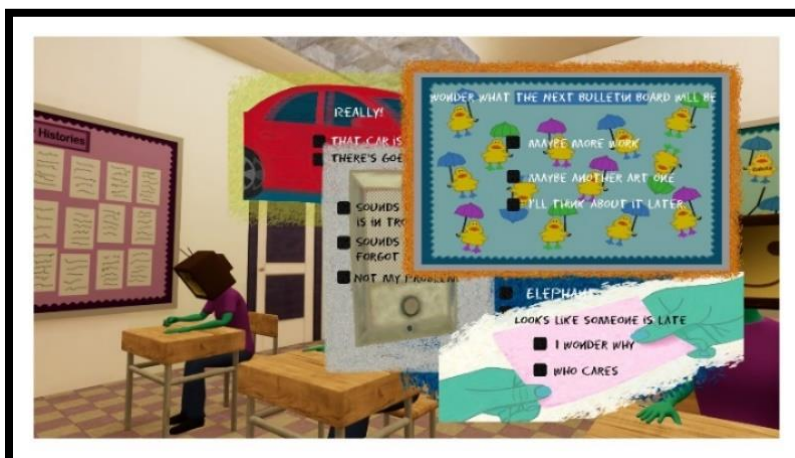


Figure 3.4 “The Inattentive Mind” – Classroom Level Image 1

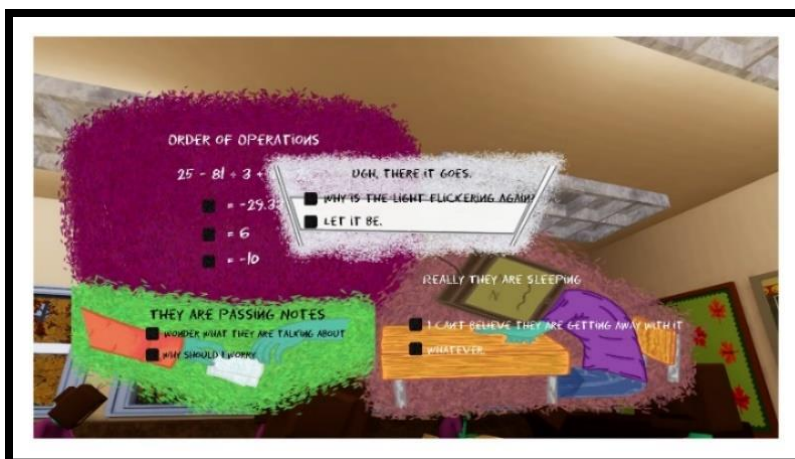


Figure 3.5 “The Inattentive Mind” – Classroom Level Image 2

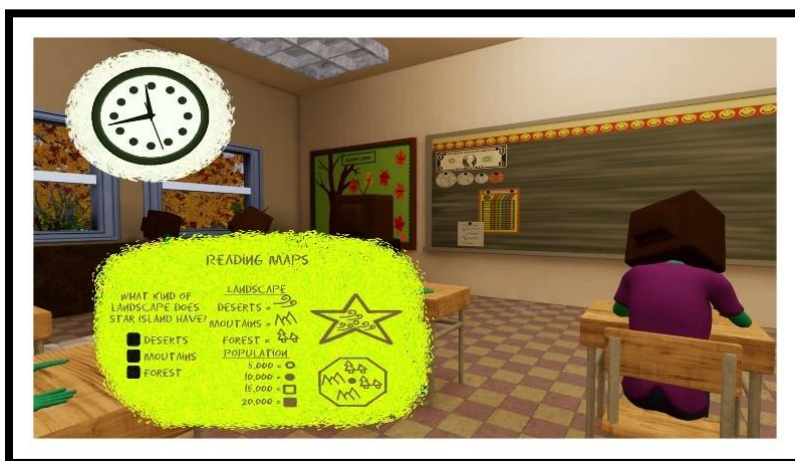


Figure 3.6 “The Inattentive Mind” – Classroom Level Image 3

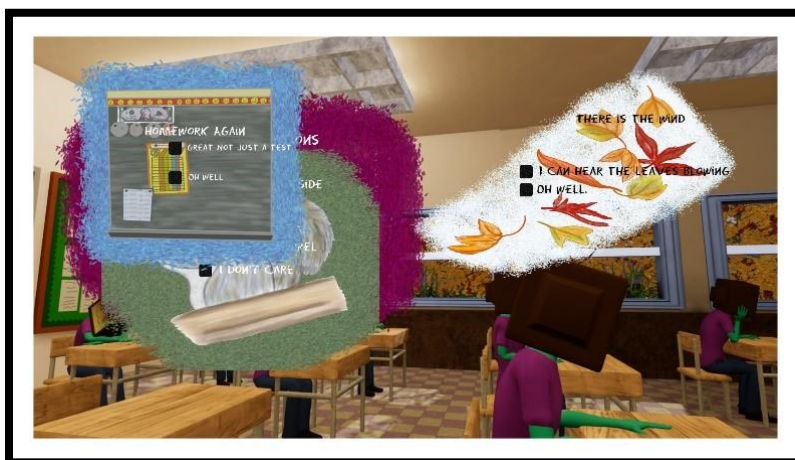


Figure 3.7 “The Inattentive Mind” – Classroom Level Image 4

3.2 Typology and Framework

My newly developed serious game application, “The Inattentive Mind”, was researched using an experimental design. The design tested an experimental and control group using already developed attention testing methods over pre- and post-tests. For accurate information on performance of participants within the experimental setting, testing was conducted in a controlled environment. This environment was a lab open to all individuals; however, during testing individuals who came into the lab were asked to respect participants and stay quiet. If distractions occurred during testing participants were asked to pause and wait for the distraction to subside before continuing.

Testing was carried out over a two-week period, in which participants were asked to come in two different days for testing sessions. Testers were asked to come in for the second round of testing at least one day after their first round. Testing for each participant took about five minutes on the first day and fifteen minutes on the second day of testing. The first day consisted of taking the Multiple Object Tracking (MOT) test, Stroop Version 1 test and Stroop Version 2 test. The second day of testing consisted of playing the game and taking the same three tests again and completing a four-point Likert Scale evaluation over the game. The order of playing the game and completing the tested varied from the control to the experimental groups. The control group completed the three tests before playing the game, while the experimental group completed the game before the tests.

The reasoning behind testers coming in for a second round of testing was to try and eliminate confounding variable of individuals thinking about their attention and causing themselves to increase or decrease their attention on their own. The control group was used to eliminate possibility of the Hawthorne effect due to the playing of my game. The use of a pre- and post-tests where to give the ability to compare results from both tests to see if there were changes

in participants results. Multiple tests were used for the pre- and post-test to gather an adequate amount of data for measuring attention, since attention is not just a variable that can be measured, but a trait of a person. The reasoning behind my use of the 4-point Likert scale was to eliminate participants from choosing a neutral rating in the evaluation. The neutral rating would not allow me to get a constructive understanding of what should be looked at to improve the game.

3.3 Sampling Population

The sampling population was made up of volunteers in West Lafayette and the Lafayette area that were not taking any medication for attention at the time of testing. The volunteers were not diagnosed with ASD and were able to use a computer software without needing assistance. They all had at least a 4th grade education and were over the age of 18. Both individuals that play video games on a regular basis (video gamers) and individuals that don't play video games (non-video gamers) were tested. Diverse genders and nationalities were included in the sampling pool as well as participants with different levels of attention skills.

3.4 Sampling Approach

The study parameters were to gather 30-40 individuals randomly from volunteers interested in participating in the experiment. When subjects volunteered they were asked to sign a consent form and identify their level of gaming experience whether they were an avid gamer or did not game. After this information was gathered the subjects were then stratified and placed into the control or experimental group. They were then drawn a number letter combination from an envelope to identify them for the rest of the study. The method of stratifying the individuals allowed for an even distribution of both video gamers and non-video gamers within both the control and experimental groups. The actual testing included a total of 34 volunteers. However,

only 32 of those volunteers came back to complete the second day of testing. Data for the two volunteers who did not return was eliminated from the analysis.

3.5 Assessment and Variables

The testing consisted of two versions of the Stroop Color Word Test, the Multiple Object Tracking (MOT) Test, and an evaluation form made around my game. The Stroop Tests and the MOT Test were used for the pre- and post-test within the experiment. The evaluation form was only administered after participants had completed playing the game. The Stroop Tests and the MOT Test were used to gather a qualitative analysis of participants. The evaluation form gathered a quantitative analysis on the participants' thoughts after playing the game. In addition, to the evaluation data, and the pre- and post-test variables, the game recorded data on the accuracy of answering questions and the participants interaction with stimuli.

The first version of the Stroop Test had participants identify the color of the word and pressing the corresponding button, as shown in figure 3.1 and 3.2. The variables measured in the Stroop Version One Test were accuracy and time. The test measured the time it took participants to identify nine words' colors. The test also measured the number of words that were misidentified.

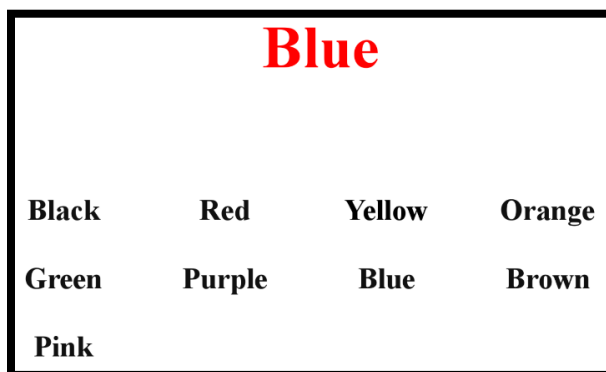


Figure 3.8 Stroop Version One Example 1

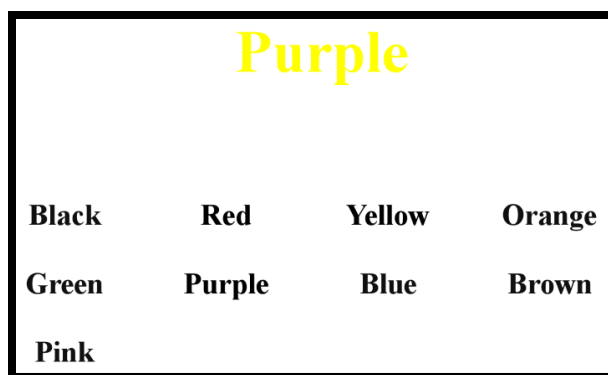


Figure 3.9 Stroop Version One Example 2

The second version of the Stroop Test had participants read aloud the color of words in two paragraphs. They were first given a paragraph where the words and the color of the words were the same, as shown in figure 3.3. The second paragraph the words and the color of the words could be different, as shown in figure 3.4. The variable measured in the Stroop Version Two Test was time. Accuracy was not measured because participants were asked to correct any mistakes made while reading the paragraph. The time measured was over how long it took the participants to read the two paragraphs.

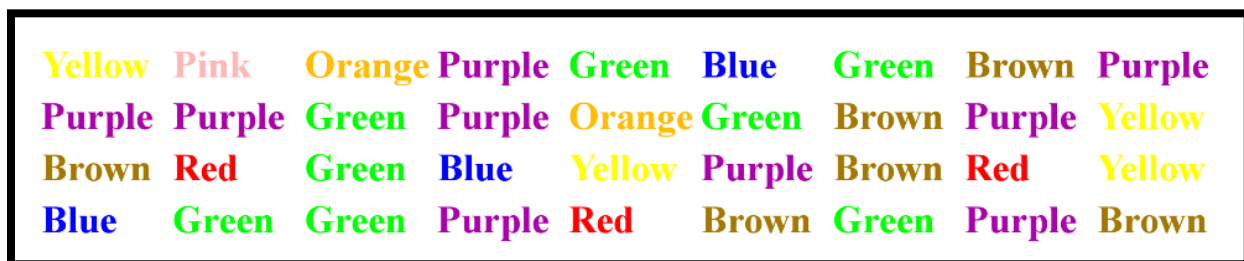


Figure 3.10 Stroop Version Two – Example of first paragraph



Figure 3.11 Stroop Version Two – Example of second paragraph

The MOT Test asked participants to view twelve identical objects and keep track of five that would flash at the start of the test, as shown in figure 3.5. The objects stopped flashing after 15 seconds and then all the objects started to move around the screen simultaneously. Once all the objects had stopped moving, the participants were asked to identify and click on the five objects they were tracking, as seen in figure 3.6. The MOT test gathered the variables of time and accuracy of identifying the five tracked objects. The variable of time measured the amount of time after the objects had stopped moving to the time the last object was selected. The accuracy was measured by the proportion of the object that were selected correctly.

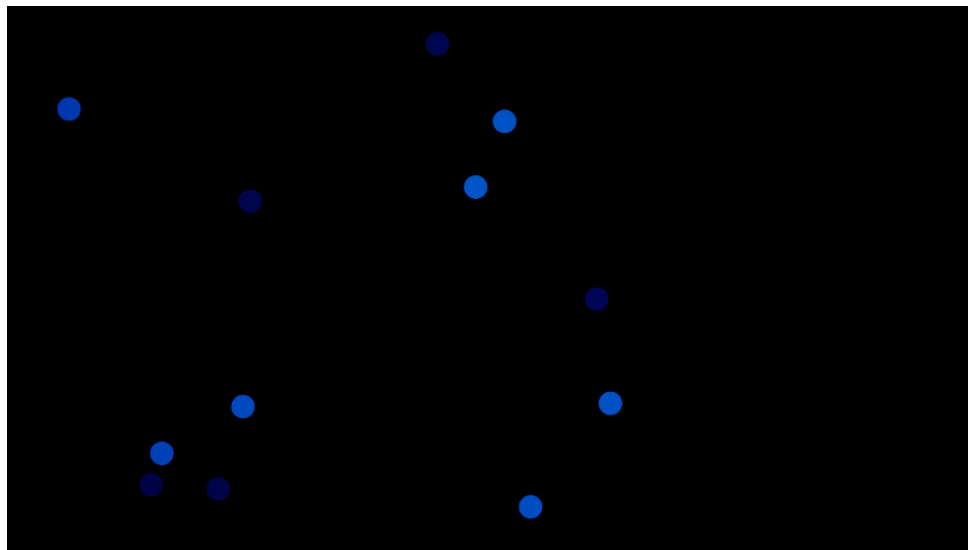


Figure 3.12 Multiple Object Tracking Test The darker circles are the flashing object to be tracked.

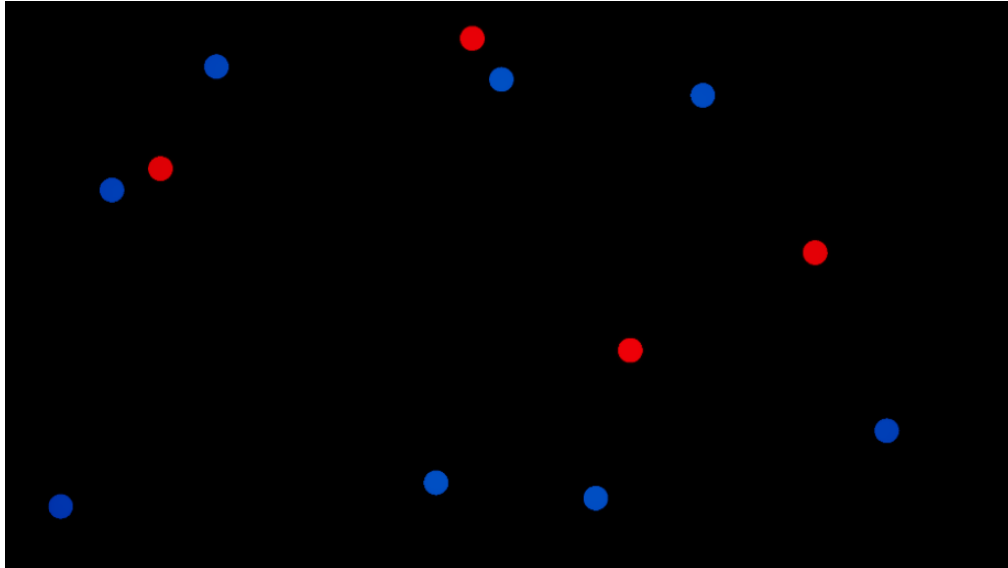


Figure 3.13 Multiple Object Tracking Test. The red objects are the ones selected after movement has finished.

My evaluation form, as seen in figure 3.7, was administered to both groups after completing the game. The form was used to gather a quick understanding of participants thoughts on the mechanics, story, and the game itself. The evaluation also was used to gain an understanding of whether participants felt they had learned anything about ADHD from playing the game.

A Study of an ADHD Experience Video Game's Effect on Users' Attention			
Evaluation			
1. What did you think about the video game?			
1	2	3	4
Disliked			Liked
2. Did you feel there was a story with the video game?			
1	2	3	4
No Story Defined			Understandable Story Defined
3. What did you think about the mechanics of the video game?			
1	2	3	4
Disliked			Liked
4. Do you feel you learned anything about ADHD from the video game?			
1	2	3	4
Didn't learn anything			Now know more about the ADHD experience

Figure 3.14 Evaluation Form

3.6 Data Analysis

Data from the pre- and post-tests were analyzed quantitatively to gather a conclusion to the first proposed research question found in section 1.4. This data was analyzed by comparing the pre- and post-test results for the control group as well as the experimental group. After comparisons were made between the pre- and post-test, there was an analysis of how the experimental group performed over the control group. This analysis consisted of a two-sample T-test, and a two-sample proportion test.

Data from the evaluation form was analyzed qualitatively to form a conclusion to the second proposed research question found in section 1.4. The evaluation's data was looked at to

discuss difficulties in understanding game mechanics, story, and understanding of the ADHD experience. An analysis was also made to address how successful the game was at stimulating enjoyment. As mentioned in section 2.2.5, Frustration and Enjoyment, a lack of interest in a game could cause individuals to stop playing the game and miss a learning opportunity. If this game were to be used in the future a recognition of how the game is perceived would be needed.

3.7 Hypothesis

My proposed game application was hypothesized to increase the attention skills of participants. Proof of this hypothesis was to show a significant lower difference in post-test averages between the experimental and control groups, with the experimental group results being higher. Furthermore, this experiment was expected to provide significant evidence of enjoyment of the game and a better understanding of ADHD or inattention problems. Satisfactory understanding of ADHD and attention improvement was expected to come from the playing of this game.

$H_{\alpha \text{ attention}}$ = The experimental group will have a significantly higher increase in attention skills than the control.

$H_{0 \text{ attention}}$ = The experimental group will not have a significant difference in attention skills than the control.

$H_{\alpha \text{ empathy}}$ = The participant had a better understanding of ADHD after playing “The Inattentive Mind”.

$H_{0 \text{ empathy}}$ = The participant did not have a better understanding of ADHD after playing “The Inattentive Mind”.

RESULTS

4.1 Attention Testing Results

The data gathered from the pre- and post-test were analyzed using Microsoft Excel and SPSS Statistics 25 software packages. The variables that were reviewed and analyzed consisted of the time gathered from the Stroop Version One and Two and the accuracy proportion of the Multiple Object Tracking test. The variables of time were analyzed using a two-sample comparison mean T-test. The variables of accuracy proportion were analyzed using a two-sample proportion test.

4.1.1 Stroop Version One Results

From the data gathered over the Stroop Version One, a statistical analysis was performed on the time differences between pre- and post-test using a two-sample comparison mean T-test. This test was performed at a 95% confidence interval. The null hypothesis for this test was that the mean time difference of the experimental group was equal to the mean time difference for the control group. The alternative hypothesis was that the mean time difference for the experimental group would be greater than the control group's mean time difference.

Null Hypothesis: $\mu_{\text{Treatment}} = \mu_{\text{Control}}$

Alternative Hypothesis: $\mu_{\text{Treatment}} > \mu_{\text{Control}}$

If the experimental group's mean time difference was to be greater, this in turn would constitute that the game intervention would result in an increase in attention skills. The test statistic used was equal to the standard deviation of the experimental group's time difference minus the standard deviation of the control group's time difference. This was then divided by the standard error of the pooled participants.

$$\text{Test statistic } t = \frac{(\bar{y}_{\text{Treatment}} - \bar{y}_{\text{Control}})}{\text{Pooled S.E.}}$$

The results of this T-test were a P-value of 0.225. This number being greater than a 0.05 provides inconclusive evidence for rejection or acceptance of the null hypothesis. The resulting means, standard deviations, and standard error mean can be found below in table 4.1 followed by the significance graph in figure 4.1.

Table 4.1 Stroop V1 statistics

Group Statistics					
	group label	N	Mean	Std. Deviation	Std. Error Mean
ST1 time Difference	Control	15	5.2191866666 66667	10.4620261148 20935	2.701283527352 571
	Experimental	17	2.5676458823 52941	9.15626355911 9010	2.220720105308 328

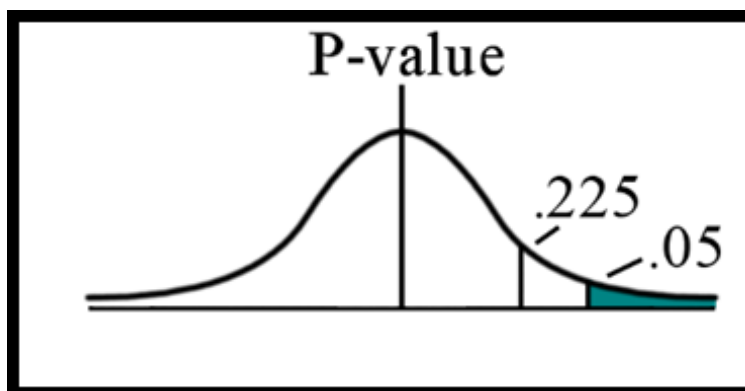


Figure 4.1 Stroop V1 P-Value Graph

4.1.2 Stroop Version Two Results

From the data gathered over the Stroop Version Two, a statistical analysis was performed on the time differences between pre- and post-test using a two-sample comparison mean T-test. This test was performed at a 95% confidence interval. The null hypothesis for this test was that the mean time difference of the experimental group was equal to the mean time difference for the

control group. The alternative hypothesis was that the mean time difference for the experimental group would be greater than the control group's mean time difference.

Null Hypothesis: $\mu_{\text{Treatment}} = \mu_{\text{Control}}$

Alternative Hypothesis: $\mu_{\text{Treatment}} > \mu_{\text{Control}}$

If the experimental group's mean time difference was to be greater this in turn would constitute that the game intervention would result in an increase in attention skills. To conduct this statistical test the test statistic used was equal to the standard deviation of the experimental group's time difference minus the standard deviation of the control group's time difference. This was then divided by the standard error of the pooled participants.

$$\text{Test statistic } t = \frac{(\bar{y}_{\text{Treatment}} - \bar{y}_{\text{Control}})}{\text{Pooled S.E.}}$$

The results of this T-test were a P-Value of 0.3345. This number being greater than a 0.05 provides inconclusive evidence for rejection or acceptance of the null hypothesis. The resulting means, standard deviations, and standard error mean can be found below in table 4.2 followed by the significance graph in figure 4.2.

Table 4.2 Stroop V2 Statistics

Group Statistics					
	group label	N	Mean	Std. Deviation	Std. Error Mean
ST2 time difference	Control	15	4.54035200000000	7.528327719163893	1.943805858740895
	Experimental	17	5.69040000000000	7.514367685579906	1.822501863374945

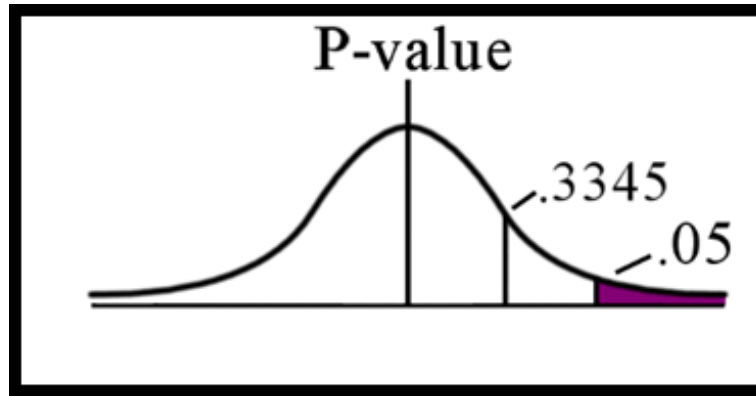


Figure 4.2 Stroop V2 P-Value Graph

4.1.3 Multiple Object Tracking Results

From the data gathered over the Multiple Object Tracking, a statistical analysis was performed over the proportion of post-test using a two-sample proportion test. This test was performed at a 95% confidence interval. The null hypothesis for this test was that the post-test accuracy proportion of the experimental group was equal to the post-test accuracy proportion for the control group. The alternative hypothesis was that the post-test accuracy proportion for the experimental group would be greater than the control group's post-test accuracy proportion.

Null Hypothesis: $p_{\text{Treatment.post}} = p_{\text{Control.post}}$

Alternative Hypothesis: $p_{\text{Treatment.post}} > p_{\text{Control.post}}$

If the experimental group's post-test accuracy proportion was to be greater, this in turn would constitute that the game intervention would result in an increase in attention skills. The test statistic used was equal to the mean post-test proportion of the experimental group minus the mean post-test proportion of the control group. This was then divided by the standard error of the pooled participants.

$$\text{Test statistic } z = \frac{(\hat{p}_{\text{Treatment.post}} - \hat{p}_{\text{Control.post}})}{\text{Pooled S.E.}}$$

The results of this proportion test were a P-Value of 0.390675. This number being greater than a 0.05 provides inconclusive evidence for rejection or acceptance of the null hypothesis. The results of the two-sample proportion test can be found below in table 4.3 followed by the significance graph in figure 4.3.

Table 4.3 Multiple Object Tracking Statistics

Two-sample proportion tests	
p_control	0.253333
p_experimental	0.211765
n1	15
n2	17
s.e.	0.149764
z	-0.27756
pvalue	0.390675

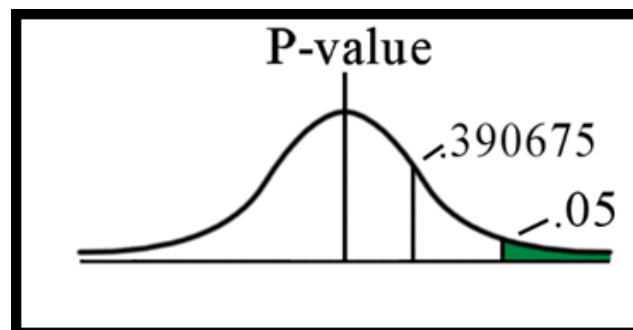


Figure 4.3 MOT P-Value Graph

4.2 Attention Testing Analysis

The results of both the two-sample T-tests and the two-sample proportion test provides insignificant evidence to support a rejection or acceptance of the null attention hypothesis. However, these statistic tests provide evidence for the need to further test with a larger sample size to understand the inconclusive results. As there is not a significant difference between results of the control and experimental groups, there are still variances that can be found. Within the results of the Stroop Version One Test, evidence showed that the mean time difference for the control

group was greater than the experimental. The Stroop Version Two test showed the opposite effect with the experimental group having a greater mean time difference. Further testing could determine whether there is a significant change in these mean time differences and whether the two variations of the Stroop test provide opposing results.

Additionally, an investigation over the Multiple Object Tracking Test should be made to understand whether the post-test proportions could yield a greater distinction between the control and experimental. Further testing should be done to uncover possible discrepancies between the Stroop test and the Multiple Object test as these tests measure attention using two different modalities. Future testing could uncover discrepancies of one test possibly rejecting the null hypothesis, while the other accepts the null hypothesis.

4.3 Evaluation Results

The responses of the evaluation form were gathered and formatted to understand how the game was interpreted. The results can be found in figure 4.4 below. From these results an overall positive response for the questions covering the story, likability, and ADHD understanding can be found. In terms of the mechanics of the game there was a split between negative and positive responses. Along with these response results some participants gave comments on their evaluation forms and in person. These comments were recorded and analyzed with the responses to gather a deeper understanding of participants views. The resulting comments are listed below.

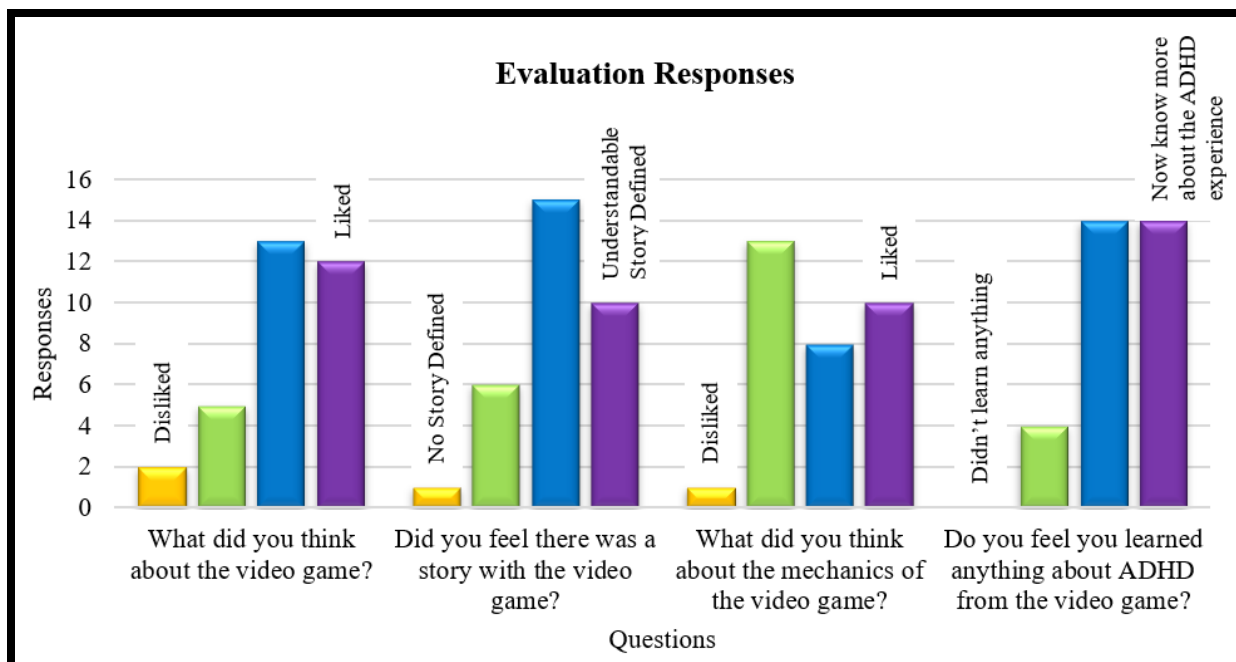


Figure 4.4 Evaluation Responses

4.3.1 Participant Comments

A participant stated that they highly enjoyed the game, but they were annoyed by it. They expressed a feeling that there wasn't a defined story because it seemed to much like a typical day. Another participant had commented "I have ADHD actually, so this fits me. Nice research study." A third participant said "Wait, is that really how it feels to have ADHD! Because that would suck." Other participants shared similar comments stating that they felt the game did a good job at capturing ADHD.

4.4 Evaluation Analysis

These results from the evaluation can be analyzed to understand how the game was received by the participants. From interpreting the bar chart in Figure 4.4, the video game was shown to be liked and have a defined story to most participants as 25 of the 32 participants answered positively

with both questions. A clear majority felt the game had increased their understanding of ADHD with 28 participants having responded positively. However, as addressed from the comments made by participants, the story seemed simple due to it feeling just like a regular day of class. In addition to the story and game being enjoyed, the evaluations depicted the split in opinions of the game mechanics, with 20 positive responses and 12 negative responses. This split can be analyzed with the understanding that controls were not like other games. As the game mechanics were designed to give the feeling of ADHD with an unease of use to participants.

Overall the results that are taken away from the qualitative analysis of “The Inattentive Mind” are positive. The evaluations as well as the comments support a strong enjoyment and empathetic understanding of ADHD and inattention problems. These findings lead to the conclusion of the game being successful to accept the alternative empathy hypothesis. The evaluation can also be used to comprehend how edits to the story and mechanics may improve the overall enjoyment further.

DISCUSSION

5.1 Summary

CHAPTER 5
Video games have the potential for improving attention skills outside of play. Understanding this potential, I was able to gather past research to lay a foundation for the creation of my game, “The Inattentive Mind”. This game used the methods of overstimulation to simulate my experience with ADHD, while still focusing on game satisfaction, possibilities of frustration, and understanding of the storyline. My game was tested using an experimental design with pre-test, game intervention, post-test and evaluation to measure the successes and failures. The most significant contribution of my game was the increased awareness of the ADHD experience.

5.2 Conclusions

I concluded that the game, “The Inattentive Mind”, was a successful project. The game used the foundation of past studies to build its testing procedures. The use of the pre- and post-tests with a control group provided the platform for understanding that the game may have a potential for changing attention. Although not enough evidence was found to accept or reject the attention hypothesis, we can understand that more data would need to be gathered to make a conclusion. This study and past studies can help us to understand that video games are a possible tool for changing attention within the real world.

The game can also be used to comprehend the impact playing it can have on others perception of ADHD. This game provided both enjoyment and engagement, which helped lead individuals to feel empathy towards ADHD. The game’s use of stimuli was able to convey the feeling of ADHD, while not losing participants understanding of what the game was about. Therefore, the game was able to gather results to prove acceptance of the empathy hypothesis.

Even if further testing shared information to reject the null attention hypothesis, we can still understand that the game was able to help individuals gain empathy towards ADHD and inattention problems.

5.3 Limitations

Though there was not significant evidence supporting a change in attention, we should look at how the testing time may have affected this. There could have been a difference in attention if the game may have taken longer than ten minutes or if the game were to be played more than once. If the game were longer, thereby increasing the amount of time with participants, results may have differed. Additionally, if there were more play sessions the results may have differed.

The major limitations of my research were the time spent running the data collection and the pool of participants that took part in the study. If the research team was more than one person conducting the study, the sampling pool of participants could have been larger. Additionally, if other alternatives were used to conduct the study, such as the possibility of testing participants online, the sampling pool could have been larger in this situation as well.

Other limitations consisted of the participants needing to fit within a certain demographic group. If the study had consisted of participants outside of the Lafayette and West Lafayette communities, the data may have gathered more diversity in education levels of participants. Another limitation of this study was the exclusion of participants who were currently taking medication for attention. While many of the people taking medications for attention carry the diagnosis of ADHD, there are people that take medications for attention other than ADHD that may have been excluded from this study. By excluding this population from the study, it is not known whether participation in this study would have increased their awareness of ADHD.

Additionally, the use of a four-point Likert Scale could be seen as less valid to the five- or seven-point Likert Scales. This is because there is a lack of a neutral stance the participant can take when addressing the evaluation questions. Changing the Likert Scale could produce different results of the evaluation.

Researcher bias could also be seen as a possible limitation of my study, due to the fact that I have ADHD and was lead researcher and the creator of my game. However, I did my best to stay impartial during my investigation by understanding from the beginning that my study may not gather positive data to support a finding of what my game set out to do. In conjunction, others may see this relationship to the subject matter causing a threat to internal validity. As there could have been other methods of testing attention that may have been overlooked.

5.4 Recommendations for Future Research

If my project was to be taken further, testing with a larger sample size would need to be conducted. Due to the small size of the data gathered, my game cannot prove or disprove that it can improve a player's attention skills. Furthermore, additional tests may be needed to understand if the game can help improve some forms of attention, if not all forms of attention. Additionally, I feel that the individuals who research my game further would need to have a strong connection to ADHD and inattention problems. Without the strong connection, I worry that the game and research would lose its validity. I believe that it is necessary to have a connection or understanding of ADHD or inattention problems to do this research justice. With their connection to ADHD and inattention problems, individuals can use their own experiences to make possible changes that could improve my game or expand the impact, whether it be more content or slight changes to the game's mechanics.

APPENDIX A. TABLE OF LITERATURE

In-Text Citation	Title	Authors	Form of media	Impact of work
(Alhadi et al., 2017)	The association between time spent on computer tablets and attention deficit hyperactivity disorder (ADHD) among children from 3 to 12 years old	Alhadi, A., Abid, O. A., Alsuhaibani, K. A., Alshehri, K. A., Alowaisheq, R. A., & Backer, N. B. Al.	Journal article	Impact of computer tablet usage on children with ADHD
(Barbieri et al., 2017)	Pedestrian Inattention Blindness While Playing Pokémon Go as an Emerging Health-Risk Behavior: A Case Report	Barbieri, S., Vettore, G., Pietrantonio, V., Snenghi, R., Tredese, A., Bergamini, M., Previato, S., Stefanati, A., Gaudio, R. M., Feltracco, P.	Journal article	Inattention blindness, and how games can make individuals lose focus of outside surroundings.
(Bavelier, 2012)	Your brain on video games	Bavelier, D.	TED Talk	Gives an overview of methods of testing attention. Describes a positive relationship between attention and video games.
(Bul et al., 2015)	Development and User Satisfaction of Plan-It Commander,” a Serious Game for Children with ADHD.	Bul, K. C M, Franken, I. H A, Van Der Oord, S., Kato, P. M, Danckaerts, M., Vreeke, L. J, Willems, A., Van Oers, H. J J, Van Den Heuvel, R., Van Slagmaat, R., Cmd, B, Maras, A.	Journal article	Testing method of individuals with ADHD. Development of serious game for ADHD advancement. Implication of developing serious games.

In-Text Citation	Title	Authors	Form of media	Impact of work
(Chatfield, 2010)	7 ways video games engage the brain	Chatfield, T.	TED Talk	Discussed needs for games to increase engagement and benefits.
(de la Guía, Lozano, & Penichet, 2015)	Educational games based on distributed and tangible user interfaces to stimulate cognitive abilities in children with ADHD.	de la Guía, E., Lozano, M. D., & Penichet, V. M. R.	Journal article	Discusses testing methods of serious games and how in game frustration can affect players.
(Ferguson, 2015)	Do Angry Birds Make for Angry Children? A Meta-Analysis of Video Game Influences on Children's and Adolescents' Aggression, Mental Health, Prosocial Behavior, and Academic Performance	Ferguson, C. J.	Journal article	Influence of games on individuals' moods and mental health.
(Ferrara, 2013)	Games for Persuasion: Argumentation, Procedurality, and the Lie of Gamification	Ferrara, J	Journal article	Addresses the value of games and the uses for solving problems.
(Metcalf & Pammer, 2014)	Impulsivity and Related Neuropsychological Features in Regular and Addictive First Person Shooter Gaming.	Metcalf, O., & Pammer, K.	Journal article	Covers the nature of inattention and disinhibition as seen in games.

In-Text Citation	Title	Authors	Form of media	Impact of work
(Nikkelen, Valkenburg, Huizinga, & Bushman, 2014)	Media use and ADHD-related behaviors in children and adolescents: A meta-analysis	Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J.	Journal article	Views the relationship of ADHD behaviors and media. Addresses factors that influence strength of media relation. States hypothesis of inattention.
(Rego, Rocha, Faria, Reis, & Moreira, 2017)	A Serious Games Platform for Cognitive Rehabilitation with Preliminary Evaluation.	Rego, P. A., Rocha, R., Faria, B. M., Reis, L. P., & Moreira, P. M.	Journal article	Discusses multimodal user interfaces for games, and effective training attributes for serious games.
(Strahler Rivero, Herrera Nuñez, Uehara Pires, & Amodeo Bueno, 2015)	ADHD Rehabilitation through Video Gaming: A Systematic Review Using PRISMA Guidelines of the Current Findings and the Associated Risk of Bias.	Strahler Rivero, T., Herrera Nuñez, L. M., Uehara Pires, E., & Amodeo Bueno, O. F.	Journal article	Discusses how medication of users can affect testing. Addresses how video games are useful in drilling and practicing skills.
(Vallett, Lamb, & Annetta, 2013)	The gorilla in the room: The impacts of video-game play on visual attention.	Vallett, D. B., Lamb, R. L., & Annetta, L. A.	Journal article	Addresses inattention blindness, and spatial ability when playing video games.
(Weerdmeester, Cima, Granic, Hashemian, & Gotsis, 2016)	A Feasibility Study on the Effectiveness of a Full-Body Videogame Intervention for Decreasing Attention Deficit Hyperactivity Disorder Symptoms.	Weerdmeester, J., Cima, M., Granic, I., Hashemian, Y., & Gotsis, M	Journal article	Discusses the significances of a control group verses an experimental group. Addresses positive and negative effects of repetition within gameplay. Full-Body-Driven intervention with in a video game.

APPENDIX B. TESTING MATERIALS

A Study of an ADHD Experience Video Game's Effect on Users' Attention

Evaluation

1. What did you think about the video game?

1

2

3

4

Disliked

Liked

2. Did you feel there was a story with the video game?

1

2

3

4

No Story Defined

Understandable
Story Defined

3. What did you think about the mechanics of the video game?

1

2

3

4

Disliked

Liked

4. Do you feel you learned anything about ADHD from the video game?

1

2

3

4

Didn't learn
anything

Now know more
about the ADHD
experience

REFERENCES

- Alhadi, A., Abid, O. A., Alsuhaibani, K. A., Alshehri, K. A., Alowaisheq, R. A., & Backer, N. B. Al. (2017). The association between time spent on computer tablets and attention deficit hyperactivity disorder (ADHD) among children from 3 to 12 years old. *European Psychiatry*, 41, S146. <https://doi.org/10.1016/j.eurpsy.2017.01.1990>
- Barbieri, S., Vettore, G., Pietrantonio, V., Snenghi, R., Tredese, A., Bergamini, M., ... Feltracco, P. (2017). Pedestrian Inattention Blindness While Playing Pokémon Go as an Emerging Health-Risk Behavior: A Case Report. *J Med Internet Res*, 19(4), 86–861. <https://doi.org/10.2196/jmir.6596>
- Bavelier, D. (2012). *Your brain on video games*. YouTube. Retrieved from <https://www.youtube.com/watch?v=FktsFcooIG8>
- Bul, K. C. M., Franken, I. H. A., Van Der Oord, S., Kato, P. M., Danckaerts, M., Vreeke, L. J., ... Maras, A. (2015). Development and User Satisfaction of Plan-It Commander, ' a Serious Game for Children with ADHD. *Games for Health Journal*, 4(6), 502–512. <https://doi.org/10.1089/g4h.2015.0021>
- CHADD – The National Resource on ADHD. (2018). General Prevalence of ADHD | CHADD. Retrieved February 24, 2018, from <http://www.chadd.org/understanding-adhd/about-adhd/data-and-statistics/general-prevalence.aspx>
- Chatfield, T. (2010). *7 ways video games engage the brain*. YouTube. Retrieved from <https://www.youtube.com/watch?v=KyamsZXXF2w>
- Childress, A., & Sallee, F. R. (2013, September). The use of methylphenidate hydrochloride extended-release oral suspension for the treatment of ADHD. Retrieved January 30, 2019, from <http://www.tandfonline.com/doi/abs/10.1586/14737175.2013.833002>
- Clanton, R. (2013, November 9). Example of Stroop Effect experiment [Digital image]. Retrieved November 14, 2018, from [http://mercercognitivepsychology.pbworks.com/w/page/70683216/Stroop Effect](http://mercercognitivepsychology.pbworks.com/w/page/70683216/Stroop%20Effect)
- de la Guía, E., Lozano, M. D., & Penichet, V. M. R. (2015). Educational games based on distributed and tangible user interfaces to stimulate cognitive abilities in children with ADHD. *British Journal of Educational Technology*, 46(3), 664–678. <https://doi.org/10.1111/bjet.12165>
- Dictionary.com. (2018). Video game. Retrieved February 24, 2018, from <http://www.dictionary.com/browse/video-game>
- Dunckley, V. L. (2014, February 01). Why Can My Inattentive Child Pay Attention to Video Games?! Retrieved February 01, 2018, from <https://www.psychologytoday.com/blog/>

- Ferguson, C. J. (2015). Do Angry Birds Make for Angry Children? A Meta-Analysis of Video Game Influences on Children's and Adolescents' Aggression, Mental Health, Prosocial Behavior, and Academic Performance. *Perspectives on Psychological Science*, 10(5), 646–666. <https://doi.org/10.1177/1745691615592234>
- Howe, P. D., & Holcombe, A. O. (2012, August 27). The stimulus sequence used in Experiment 1 [Digital image]. Retrieved November 14, 2018, from <https://www.frontiersin.org/articles/10.3389/fpsyg.2012.00307/full>
- Leng, J., & Sharrock, W. W. (2012). *Handbook of research on computational science and engineering: theory and practice*.
- Luo, L., Cai, W., Zhou, S., Lees, M., & Yin, H. (2015). A review of interactive narrative systems and technologies: A training perspective. *Simulation*, 91(2), 126-147. doi:10.1177/0037549714566722\
- Macleod, C. M., & Macdonald, P. A. (2000). Interdimensional interference in the Stroop effect: Uncovering the cognitive and neural anatomy of attention. *Trends in Cognitive Sciences*, 4(10), 383-391. doi:10.1016/s1364-6613(00)01530-8
- Metcalf, O., & Pammer, K. (2014). Impulsivity and Related Neuropsychological Features in Regular and Addictive First Person Shooter Gaming. *Cyberpsychology, Behavior, and Social Networking*, 17(3), 147–152. <https://doi.org/10.1089/cyber.2013.0024>
- National Institute of Mental Health. (2016, March). Attention Deficit Hyperactivity Disorder. Retrieved February 12, 2018, from <https://www.nimh.nih.gov/health/topics/attention-deficit-hyperactivity-disorder-adhd/index.shtml>
- Nikkelen, S. W. C., Valkenburg, P. M., Huizinga, M., & Bushman, B. J. (2014). Media use and ADHD-related behaviors in children and adolescents: A meta-analysis. *Developmental Psychology*, 50(9), 2228–2241. <https://doi.org/10.1037/a0037318>
- Raz, A. (2004). Brain Imaging Data of ADHD. *Psychiatric Times*, 42. Retrieved November 14, 2018, from http://link.galegroup.com/apps/doc/A121548839/HRCA?u=purdue_main&sid=HRCA&xid=c81f2987
- Rego, P. A., Rocha, R., Faria, B. M., Reis, L. P., & Moreira, P. M. (2017). A Serious Games Platform for Cognitive Rehabilitation with Preliminary Evaluation. *Journal of Medical Systems*, 41(1), 10. <https://doi.org/10.1007/s10916-016-0656-5>
- Riedl, M. O., & Bulitko, V. (2013, March 22). Interactive Narrative: An Intelligent Systems Approach. *AI Magazine*. mental-wealth.org/201402/why-can-my-inattentive-child-pay-attention-video-games
- Rouse, M. (2005, April 05). What is user interface (UI)? - Definition from WhatIs.com. Retrieved April 05, 2018, from <https://searchmicroservices.techtarget.com/definition/user-interface-UI>

- Scarpina, F., & Tagini, S. (2017). The Stroop Color and Word Test. *Frontiers in Psychology*, 8. doi:10.3389/fpsyg.2017.00557
- Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattention blindness for dynamic events. *Perception*, 28(9), 1059-1074. doi:10.1068/p2952
- Strahler Rivero, T., Herrera Nuñez, L. M., Uehara Pires, E., & Amodeo Bueno, O. F. (2015). ADHD Rehabilitation through Video Gaming: A Systematic Review Using PRISMA Guidelines of the Current Findings and the Associated Risk of Bias. *Frontiers in Psychiatry*, 6. <https://doi.org/10.3389/fpsyt.2015.00151>
- Team, E. (2013, April 23). What is GBL (Game-Based Learning)? Retrieved April 05, 2018, from <http://edtechreview.in/dictionary/298-what-is-game-based-learning>
- Tran, A., & Hoffman, J. (2013). Visual Attention is Required for Multiple Object Tracking. *Journal of Vision*, 13(9), 1282-1282. doi:10.1167/13.9.1282
- Vallett, D. B., Lamb, R. L., & Annetta, L. A. (2013). The gorilla in the room: The impacts of video-game play on visual attention. *Computers in Human Behavior*, 29(6), 2183–2187. <https://doi.org/10.1016/J.CHB.2013.05.001>
- Weerdmeester, J., Cima, M., Granic, I., Hashemian, Y., & Gotsis, M. (2016). A Feasibility Study on the Effectiveness of a Full-Body Videogame Intervention for Decreasing Attention Deficit Hyperactivity Disorder Symptoms. *Games for Health Journal*, 5(4), 258–269. <https://doi.org/10.1089/g4h.2015.0103>