January 2017

Going To The Movies: Immersion, Visual Awareness, And Memory

Matthew Whalen Moran
Eastern Kentucky University

Going to the movies: Immersion, visual awareness, and memory.

By

Matthew Moran

Thesis Approved:

Chair, Advisory Committee

Member, Advisory Committee

Member, Advisory Committee

Dean, Graduate School

STATEMENT OF PERMISSION TO USE

In presenting this thesis in partial fulfillment of the requirements for a master's degree at Eastern Kentucky University, I agree that the Library shall make it available to borrowers under rules of the Library. Brief quotations from this thesis are allowable without special permission, provided that accurate acknowledgment of the source is made. Permission for extensive quotation from or reproduction of this thesis may be granted by my major professor, or in [his/her] absence, by the Head of Interlibrary Services when, in the opinion of either, the proposed use of the material is for scholarly purposes. Any copying or use of the material in this thesis for financial gain shall not be allowed without my written permission.

Signature MATTHEW MORAN

Date 11/8/2017

GOING TO THE MOVIES: IMMERSION, VISUAL AWARENESS, AND MEMORY

BY

MATTHEW MORAN

Submitted to the Faculty of the Graduate School of

Eastern Kentucky University

in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

2017

DEDICATION

This thesis is dedicated to my parents Michael and Dee Dee Moran for their unwavering support.

ACKNOWLEDGEMENTS

I would like to thank my major professor, Dr. Alex Varakin, for his guidance and patience. I would also like to thank the other committee members, Dr. Adam Lawson and Dr. Catherine Clement, for their comments and assistance over the past few years.

ABSTRACT

Immersion describes the extent of which one feels involved in a virtual experience. In immersive environments, observers report high levels of sensory interaction, story engagement, and an impression of reality. According to the concept of Inattentional Blindness (IB), many people can miss an unexpected stimulus or object even if it is in their field of vision while attending to a task. Can immersion affect susceptibility to IB, and can it affect memory performance? To answer this question, two model theaters were used in order to manipulate a person's assessment of being immersed in two experiments. A realistic condition used a model of a movie theater complete with curtains, seats, wallpaper, working wall sconces, and patrons. A haphazard condition (control) used a model of the same size, but materials were used in a way that does not resemble a movie theater. Both conditions used an IB paradigm apparatus housed beneath the stage area that moved an unexpected stimulus (movie patron or bolt) in front of a movie screen. Upon completion of a movie clip, participants were first asked if they noticed the unexpected object, and to describe what they noticed. Immersion was then measured using Jennett et al.'s (2008; *International Journal of Human Computer Studies*) questionnaire, and memory was assessed with a 10-question multiple-choice test about the movie clip. Results did not show a clear relationship between immersion and IB. Differences between groups were marginal for immersion, IB, and memory.

Keywords: Inattentional Blindness, Immersion, & Memory

Table of Contents

List of Tables

Table **Page**

List of Figures

Figure **Page**

CHAPTER 1

Introduction

In designing a questionnaire regarding immersion, Jennett, Cairns, Cox, Dhoparee, Epps, Tijs, and Walton (2008) concluded that it consists of time passing without noticing and a feeling that one is in the environment in question. Immersion can describe the extent to which one feels involved in a virtual experience. In immersive environments, observers report high levels of sensory interaction, story engagement, and an impression of reality (Jennett, Cairns, Cox, Dhoparee, Epps, Tijs, & Walton, 2008). Immersion is involved in a variety of scenarios including advancements in technology, video games, socializing in online virtual worlds, watching movies in theaters, and virtual reality.

Inattentional Blindness (IB) describes a phenomenon wherein many people can miss an unexpected stimulus or object even if it is in their field of vision while attending to a task. If someone is attending to a task like driving while looking for an address, they might miss an unexpected stimulus of a basketball rolling out into the street even if it is in their field of vision. Research on this subject led Mack and Rock (1998) to hypothesize that there is “no conscious perception without attention (p. 13).” In other words, a person will not see something without attending to it. Driving a car is just one example of how IB can affect anyone in a variety of scenarios, and this example shows the importance of this concept, as driving is a hazardous task most people perform daily.

Many environments are designed to be immersive with the idea that people will perceive these environments. Keeping in mind the earlier quote from Mack and Rock, one might surmise that attention is involved in an immersive environment. IB can occur in quite a few tested environments, but can immersion affect susceptibility to IB? Another important question is to what effect would an immersive experience have on memory of that experience? To understand what might be involved in answering such questions, literature regarding memory, IB, and immersion will be broadly reviewed. Factors of IB that will be examined include similarity, age, alcohol, noticeability of stimulus, perceptual load, working memory (WM), priming, and task difficulty. Factors of immersion that will be examined include technological advancements, video gameplay realism, social engagement, moving from one environment to another, emotion, and environment realism. Lastly, two experiments conducted to answer the question will be discussed in detail.

CHAPTER 2

Literature Review

Memory

There are multiple types of memory, long-term, short-term, and working memory (WM). Long-term memory can hold information for a long period of time, such as one's own cell phone number. Short-term memory can only hold information for a number of seconds. WM is an executive function that involves keeping relevant information while discarding irrelevant information. The relevant information is dependent on what a person is focused on, or in other words to what the person is paying attention. Attention and cognitive processes are involved in memory, and manipulating those processes can affect how memory works.

One such manipulation occurs when attention is divided at either the encoding or retrieval of memories. Past studies have found that Divided Attention (DA) at memory encoding consistently affects recall, however results were not as conclusive regarding DA at memory retrieval (Fernandes & Moscovitch, 2000). In an attempt to resolve conflicting findings about Divided Attention (DA) and memory, Fernandes and Moscovitch (2000) were able to replicate those previous findings regarding DA at memory encoding. Anything that reduces attentional resources during memory encoding will affect later recall. More importantly, Fernandes and Moscovitch found that similarity of material between the items in memory and the task at retrieval has the greatest effect. In a different DA study, researchers found similar results while adding two levels of context items, background color of presented word item and temporal order of items presented (Troyer & Craik, 2000). Troyer and Craik found that when DA is applied at memory encoding, all three types of memory were affected equally. They also found the same when applying DA at retrieval, albeit less so. Temporal order, however, was affected when DA was applied at both memory encoding and retrieval (Troyer & Craik, 2000). The authors suggest that context requires more attentional resources than simple word items. Results from DA studies support the idea that if one is allocating more attentional resources, memory might be better.

While DA at encoding can decrease memory performance, intentional encoding has the ability to improve visual memory performance. Intentional encoding occurs when a person knows that he/she will be tested on the visual material to be encoded, as opposed to incidental encoding in which a person does not know that he/she will be tested on the visual material. While results of studies show similar visual memory performance between intentional and incidental encoding, those results also found improved memory for relevant visual information (Williams, 2010; Varakin & Hale, 2014). Williams (2010) found improved memory for related distractors (category & color), and Varakin and Hale (2014) found improved memory for relevant objects (birds). Processing something as relevant, as opposed to just glancing at random visual information, can improve visual memory.

Processing something as relevant is but one level of processing, as there are other levels at which information can be processed. Trying to remember the color of something is shallow, or orthographic processing. Trying to remember something by its' sound or associated sound is medium, or phonological processing. Trying to remember the meaning of something is deep, or semantic processing. Prior research has shown that deep, semantic processing yields better memory performance (Rose and Craik, 2012; Loazia, McCabe, Youngblood, Rose, and Myerson, 2011). In attempting to answer how Levels of Processing (LoP) interacts with WM, Loazia et al., (2011) found that deeper levels of processing increased performance at a reading span task and an operation span task, and increased performance at a delayed recall test.

DA, intentional encoding, and LoP affect how memory works in different ways. Dividing attention at either encoding or retrieval will decrease memory performance (Fernandes & Moscovitch, 2000; Troyer & Craik, 2000). Intentional encoding works when visual information is relevant (Williams, 2010; Varakin & Hale, 2014). When information is processed at deeper levels, memory performance will increase (Rose and Craik, 2012; Loazia, McCabe, Youngblood, Rose, and Myerson, 2011). The question regarding immersive environments and memory, however is based on the idea that if immersive environments require more attentional resources, and attention affects memory, then immersive environments will likely affect memory. Before this question is answered though, the phenomena of IB will be further explored.

Inattentional Blindness

IB is a well-known phenomenon, which gained its notoriety when Simon & Chabris (1999) conducted their famous study involving the gorilla video. In one experiment, participants were instructed to watch a video of two teams passing basketballs. One team was wearing white, and the other team was wearing black. The participants were to count the number of passes between players of just one of the teams. In the middle on the video, a person in a gorilla suit walks into the circle of players passing basketballs, pounds his/her chest, and continues off to the other side. Participants were asked if they saw anything happen, while they were counting passes. Around 46% missed the unexpected stimulus of the person in the gorilla suit (Simons & Chabris, 1999). This happened because the participants directed their attention only to counting the passes and subsequently missed the unexpected stimulus.

IB & Similarity

Looking to refine the workings of IB from the Simons and Chabris (1999) experiment, Most et al. (2001) presented the argument that if the unexpected stimulus is similar to the attended task, then it would be more likely noticed by the participant. Their concern was that participants in Simon & Chabris' (1999) study, were instructed to focus on the black team, they were more likely to notice the gorilla (58%) versus those instructed to focus on the white team (27%). This led Most et al. (2001) to construct a study regarding similarity of the unexpected stimulus to the attended task. In this case, Most et al. (2001) had participants pay attention to either black or white Ls and Ts on a computer screen and count the number of times that the letters bounced off the edges. The unexpected stimulus was a cross that varied in color from black to white in an effort to test for the effects of similarity. The results showed that when the unexpected stimulus was the color of the letters the participants were instructed to attend to, 94% of the participants noticed the unexpected stimulus (Most, et al., 2001). This shows that the more similar the unexpected stimulus is to the attended scene, the more likely it is that people will notice it, and, conversely, it shows that the unexpected stimulus will go unnoticed as long as it differs from the attended scene. The results of the study help to explain why unexpected stimuli can go unnoticed when participants are instructed to attend to a scene.

Most (2013) went on to test similarity in another study that showed that people used categories when focusing on attended stimuli. In this design, participants were instructed to pay attention to either letters or numbers all in the same black font in which letters and numbers look extremely similar, and counted the number of times they bounced off the edges of the computer screen. The unexpected stimulus was a grey E, with 78% of those told to pay attention to letters and 33% of those told to pay attention to numbers noticing. This showed that, in this case, participants were more likely to notice the unexpected stimulus if it were in the same category as the objects for which they were told to pay attention. Here again similarity played a role in susceptibility to IB, however in this case it was based on concept similarity rather than color similarity.

IB & Age

As might be expected, aging can have an effect on susceptibility to IB. Graham & Burke (2011) used the same gorilla based IB paradigm experiment created by Simon & Chabris (1999) to see what effect aging has on IB. For the experiment, two groups were created and filled with both young (17-22 years old) and old (61 to 81 years old) participants. The first group counted passes completed by the team wearing white, and the second group counted passes completed by the team wearing black. The researchers found that regardless of group assignment, the older participants were more susceptible to IB than the younger participants, and that the younger participants were more accurate in pass counts (Graham & Burke, 2011). The researchers indicated that younger participants have more attentional resources, beyond what was needed for the task left over to notice the gorilla than did the older participants. In agreement with prior research by Most et al. (2001), Graham and Burke (2011) also found that the participants counting passes by the black team were less susceptible to IB, indicating that the reason was because of the similarity in color between the team wearing black shirts and the black color of the gorilla suit.

While aging does affect susceptibility to IB, the Graham and Burke (2011) study only examined elderly people. How does the developing mind deal with attention as it develops? Researchers aimed to answer that question running an IB study that created groups based on age comparing different stages of childhood against adults (Remmington, Cartwright-Finch, & Lavie, 2014). In this study, researchers used the line length judgement task created by Mack and Rock (1998) in which participants judged the length of lines of a cross on a computer screen, and the unexpected stimulus occurred in one of the quadrants of the screen as created by the cross. Results showed that awareness beyond the focus of attention increased with age up to adulthood, with younger children having missed the unexpected stimulus more so than adults (Remmington, Cartwright-Finch, & Lavie, 2014). The authors indicated the reason for this to be an increased perceptual capacity that comes with approaching adulthood. These experiments concerning aging and IB showed that, due to attentional resource availability and allocation, both the very young and the very old are more susceptible to IB.

IB & Alcohol

In another study using the gorilla video, researchers found that alcohol had an effect on rates of IB (Clifasefi, Takarangi, & Bergman, 2006). In that study, four groups were created based on the level of alcohol consumed prior to watching the video created by Simon & Chabris (1999). Two groups received alcohol (leading to a blood alcohol level of 0.04), with one group being told they got the placebo, and two groups did not receive alcohol (placebo), with one group being told that they did receive alcohol. Their results showed that only those who actually received alcohol had increased instances of IB with only 18% noticing the gorilla (Clifasefi, Takarangi, & Bergman, 2006). The perception that one received alcohol was not enough to induce IB. The authors indicated that because there was no placebo effect in the absence of alcohol, attentional resources are involved in the occurrence of IB.

IB & Noticeability

How noticeable was the gorilla in the original video made by Simons & Chabris (1999)? The team colors were black and white, and the gorilla suit had black fur. What about something more noticeable than a gorilla? In a study by Hyman Jr. et al. (2010), researchers used a clown riding a unicycle as the unexpected stimulus and used observations of students passing through a commonly used square of a college campus. They grouped people in terms of status: walking alone without electronics, walking and talking on a cell phone, walking while using portable music players, and people walking in pairs. A clown complete with a red nose on a unicycle wearing brightly colored clothing rode around a sculpture in the square. When those fitting the description of the groups finished walking through the square, the researchers stopped them and asked whether or not they had observed anything out of the ordinary. Their results revealed that those walking and talking on cell phones were susceptible to IB more so than the other groups (Hyman Jr., Boss, Wise, McKenzie, & Caggiano, 2010). The participants had diminished resources available for also seeing the clown on the unicycle, because they were on their phones.

What other stimuli can go unnoticed? Can familiarity with an unexpected stimulus affect whether or not it goes unnoticed? In an effort to answer these questions, Simons (2010) recreated the original gorilla video, but, this time, added a change in color of a background stage curtain and had one of the team members passing basketballs exit the scene. After viewing the new video, participants answered questions including if they noticed any changes and whether or not they were familiar with IB studies. Results for noticing the gorilla were as expected, approximately half of the unfamiliar group noticed, and all of the participants in the familiar group noticed (Simons, 2010). Dramatically fewer participants noticed either the color change or the player exiting the scene, with the familiar group performing the worst. This meant that familiarity with the gorilla video actually limited the ability to notice the other changes. Simons (2010) indicated this to be due to participants who are familiar with the gorilla video feeling they were done looking for changes because they noticed the gorilla. In other words, they expected the gorilla and then reduced or limited their own resources to the point of not noticing the other changing stimuli.

Load Induced Blindness

So far, evidence has shown that noticing an unexpected stimulus might just depend on the amount of attentional resources available to the individual. If a person is already attending to multiple items, they might miss something else in their visual field. MacDonald and Lavie (2008) looked at this in terms of load induced blindness. It is very similar to IB, but the participants are made aware of the stimulus beforehand, in that the stimulus is no longer unexpected. In their experiments, the researchers used a letter based search task and presented the extra stimulus in the border areas between the letters and the edge of the screen. The participants were instructed to search for one of two letters, and, possibly, the extra stimulus. In the high load condition, the search letters were accompanied by other letters, and, in the low load condition, the search letters were accompanied by only Os. The results showed that when the load was high, the participants were less likely to notice the extra stimulus compared to when the load was low (MacDonald & Lavie, 2008). This means that if resources are already in use, people would be less likely to notice a stimulus regardless of expectation. This is similar to task difficulty, in that, if the task is overly difficult and consuming resources, then participants will be more likely to miss much more than just an extra stimulus. The opposite should be true as well, in that, if the task is overly easy and not consuming resources, then participants will be less likely to miss any extra stimuli.

IB & Working Memory

The idea of available resources for attention eventually leads to questioning the role of working memory as it includes a mechanism for controlling the process of allocating attentional resources. Would greater control over working memory or greater working memory capacity (WMC) aid or hurt, when it comes to the phenomenon of IB? In an extension of the classic IB study with the gorilla video, Seegmiller et al. (2011) added an evaluation of WMC to see if there were differences in IB based on that capacity. The researchers administered the operation span test (OSPAN) to assess WMC and had participants watch the same video created by Simon & Chabris (1999). The OSPAN involves performing simple mathematics while remembering unrelated words (Bleckley, Foster & Engle, 2015). Afterwards, those participants were given a questionnaire regarding what they observed to assess IB. This study was able to replicate the findings of the Simon & Chabris (1999) with 58% seeing the gorilla. More importantly, however, they also found that highly task accurate participants with higher WMC were more likely to see the gorilla than the less accurate participants with lower WMC. In other words, those with lower WMC are more susceptible to IB.

WMC was also examined by Richards, Hannon, and Derakshan (2010), with an IB task very similar to that used by Most et al. (2001). The same letters from the Most et al (2001) study were used, however, in this case, the unexpected stimulus was red . WMC was measured using the OSPAN, and the automatic operation span task (AOSPAN). The AOSPAN is similar to the OSPAN with the difference being that a string of letters of varying length had to be retained as opposed to words. The results showed that participants with low WMC were more susceptible to IB than participants with high WMC, and the authors believed this to be due to a lack of attentional resources in the individual (Richards, Hannon, & Derakshan, 2010).

Richards, Hannon, Vohra, and Golan (2014) later refined their experiment to see if goal relevance would influence the rate of IB. The authors utilized the same black and white letters design, but they designed a new unexpected stimulus. In this case, the unexpected stimulus was either a black letter that changed into a white letter or a white letter that changed into a black letter. The participants were instructed to attend to the white letters, such that the black letter changing into a white letter was goal relevant, and the white letter changing into a black letter was goal irrelevant (Richards, Hannon, Vohra, & Golan, 2014). They also manipulated task difficulty by either subtracting from or adding to the total number of letters on the screen for the participants to track, and measured WMC with the AOSPAN. Richards et al. (2014) found reduced IB, when the task was easier; decreased IB for participants with high WMC, when the unexpected stimulus was goal relevant; but increased IB for participants with high WMC, when the unexpected stimulus was goal irrelevant. This shows that WM is attending to goal relevant stimuli and inhibiting goal irrelevant stimuli better in the participants with high WMC than those with low WMC (Richards, Hannon, Vohra, & Golan, 2014). This suggests that high WMC involves increased control of attentional resources.

These studies have shown evidence that supports a relationship between WMC and IB, but can WM be manipulated to affect susceptibility to IB? Fougnie et al. (2007) conducted a study that examined the executive control function of WM and susceptibility to IB. Participants were divided into two groups and verbally given either a simple letter memorization task (maintain group) or the same task with the addition of arranging the letters into alphabetical order (manipulate group) through a computer interface. The results showed that 35% from the maintain group and 68% from the manipulate group did not notice the unexpected stimulus of a clover from a Dingbats font while being tested for accuracy on the WM tasks (Fougnie & Marois, 2007). The authors indicated that it was the executive control task of alphabetizing the letters for the manipulate group that caused increased susceptibility to IB. This was supported by presenting the unexpected stimulus after alphabetizing in another experiment, in which both groups had similar levels of susceptibility to IB. The significance here is that it is not just WMC at play, but also the executive control of attentional resources.

The processes of attention appear to be involved in WM, and involve distinct regions of the brain. Todd, Fougnie, and Marois (2005) made the argument that there are two regions of the brain that deal in attention, the intraparietal sulcus (IPS) and the temporo-parietal junction (TPJ). The IPS is used, when a goal is the objective, and reduces activity in the TPJ, which responds to other stimuli relevant or not. The researchers were able to provide evidence of this with multiple fMRI based experiments ending with an IB experiment. Increasing items maintained in visual short-term memory (VSTM) reduced activity in the TPJ, with the maintenance of items having had the greatest reductive effect on VSTM (Todd et al., 2005). This maintenance of items in VSTM showed in fMRI scans that the executive function of WM was working and focused on goal directed behavior. Goal directed behavior reduced activity in the TPJ more so than non-goal directed behavior (Todd et al., 2005). In the IB experiment, participants in the higher VSTM load group were less likely to notice the unexpected stimulus of a clover from a Dingbats font than were the participants in the lower VSTM load group (Todd, Fougnie, & Marois, 2005). The load groups indicate the level at which resources are available. The lower load group had more resources available to notice the unexpected stimulus.

Is someone with high WMC more likely to notice an unexpected stimulus because they have extra resources available, or are they less likely to notice an unexpected stimulus because their WM successfully disregards the irrelevant stimulus? While the aforementioned articles did find evidence of a relationship, not all experiments have provided evidence that WMC and IB are related. As Bredemeier et al. (2012) points out in their article, the relationship between WMC and IB in the Seegmiller (2011) article was only for the participants who were highly accurate during the attendant task of counting basketball passes.

Concerned with differing results of studies regarding WM and IB, Bredemeier et al. (2012) ran their own experiment to further examine the matter. The researchers used the bouncing letters task with the black and white Ls and Ts as were used by Most et al. (2001), and used the OSPAN to test WM. The results showed evidence of a negative relationship between WM and noticing an unexpected stimulus, as participants with higher scores on the OSPAN showing less noticing of the unexpected stimulus than the participants with lower scores (Bredemeier & Simons, 2012). This study showed contradictory evidence to the connection between WM and IB.

In another example of contradictory results, the last experiment in the aforementioned MacDonald & Lavie (2008) article regarding Load Induced Blindness was run with the same letter search task as in the prior experiments but added a WM task that consisted of remembering one of two sets of numbers. For a low WM load, there was one number, and, for the high WM load, there were six numbers. The results showed no change in noticing the extra stimulus between the low and high WM load groups (MacDonald & Lavie, 2008). There were, however, a few differences between this study and the others, in that the participants were aware that the stimulus would appear, load was and IV, and a different assessment of WM than the AOSPAN was used as the DV. This study also showed contradictory evidence to the connection between WM and IB.

In yet another example of a negative relationship between IB and WM yielding contradictory results, the connection between IB and individual differences in WM was also tested by Kreitz, Furley, Memmert, and Simons (2015). In the first of their two experiments, the researchers used a line length judgment task and created two conditions for the unexpected stimulus, near to the center or far from the center (Kreitz et al. 2015). The participants also completed a set of tests aimed at assessing cognitive abilities, including the AOSPAN and the 2-back task WM assessments and two attention breadth assessments. Attention breadth refers to spatial attention as it spreads from a central point. The researchers hypothesized that the breadth assessments would predict IB in the far condition, and that the WM assessments would predict IB in the near condition. For their second experiment, Kreitz et al. (2015) used the same line length judgement task from the first experiment, but added two assessments of global/local attention styles and an additional motion based IB paradigm. The researchers wanted to answer the question, can one IB scenario predict IB on a different IB scenario? The second IB scenario involved tracking red or blue letters with an unexpected stimulus of a light grey cross. Results showed no connection between the breadth assessments, global/local attention style, and location of the unexpected stimulus (Kreitz, Furley, Memmert, & Simons, 2015). The WM assessments showed only a very weak connection with noticing the unexpected stimulus for the line judgement IB scenario, and no connection with noticing the unexpected stimulus for the object tracking IB scenario (Kreitz, Furley, Memmert, & Simons, 2015). Importantly, results showed that exposure to one IB scenario does not strongly predict the noticing of an unexpected stimulus in another IB scenario when using a different IB paradigm intermixed with the cognitive assessments (Kreitz, Furley, Memmert, & Simons, 2015). The researchers indicated that the ability to notice an unexpected stimulus is not stable across IB paradigms, and that individual differences in WM do not predict the ability to notice an unexpected stimulus. So, the evidence of a negative relationship collected by Bredemeier et al. (2012), MacDonald & Lavie (2008), and Kreitz et al. (2015) regarding WM conflicts with the evidence of a positive relationship collected by Seegmiller et al. (2011), Richards et al. (2010) (2014), Fougnie et al. (2007), and Todd et al. (2005). In these cases though, it appears that experimental manipulations of WM and WMC affect IB more so than individual differences.

IB & The Task

Priming can greatly influence whether or not items in an environment are noticed by participants. Priming prepares the mind for what it is about to experience. To test for the effects of priming, Slavich and Zimbardo (2013) used a picture of a hotel with a falling woman in the middle of committing suicide and used different priming schemas in order to see which participants would notice the falling woman. The groups were primed by being told to focus on animate objects, inanimate objects, anything unusual, or read a story about a depressed woman staying at a hotel after a break up. After stimulus presentation in 2, 3, or 4 exposures of increasing length of 2 – 10 seconds, only 2.2% of the participants across all groups saw the falling woman. Of the priming groups, only those primed with the story of the suicidal woman were more likely to notice the falling woman (12.4%). This means that the majority of the participants experienced IB for the falling woman in the picture. The authors indicated that participants did not expect to see a falling woman because it is not a normal thing to see in a photograph of a hotel front. Context, in this case, diminished the participants' ability to notice an unexpected stimulus, however it did show that priming can play a role in noticing an unexpected stimulus. Blindness in this study was induced without the presence of a difficult task and was simply based on expectations of what one might see in a photograph. This is important because it shows that a difficult task is not necessary to induce IB.

Blindness can be induced in multiple ways and does not always even need a task at all. In a study regarding stimulus color recognition and relevance, Eitam, Yeshurun, and Hassan (2013) demonstrated that people were blind to the detail of color of a second irrelevant stimulus in the absence of a task. In a group of experiments, researchers used two concentric circles varying in color, asked participants to focus on just one or the other circle, and then asked participants to recall the colors. The results showed that 18 – 25% could not correctly recall the color of the irrelevant stimulus, a phenomenon referred to as irrelevance blindness, because the blindness occurred in the absence of a task (Eitam, Yeshurun, & Hassan, 2013).

IB can, in fact, be induced in the absence of a difficult task, and in a study regarding a concept called disruption blindness, participants missed a series of disruptions in a video presentation (Levin & Varakin, 2004). In the first experiment, the researchers had participants view one of two videos containing disruptions (motion blurs or blank screens) of three durations, and then asked the participants questions regarding what they viewed. The results from the first experiment showed that a significant portion of participants failed to notice the disruption, with no significant effect of duration. In a second experiment, the researchers used shorter versions of the videos from the first experiment, but added a second set of disruptions consisting of only a blank gray solid color, and then asked participants an expanded set of questions regarding what they viewed. The results of the second experiment yielded similar results, with no significant difference between the types of disruption or the effect of duration. The authors indicated that even when just attending to a visual field, blindness can be induced. The only task given in this study was to pay attention to the visual field in the form of a video clip as opposed to counting passes in the Simon and Chabris (1999) video, and the participants still missed disruptions in the videos. The authors hypothesized that the blindness was due to attention sampling only at certain times (Levin & Varakin, 2004).

IB can be brought on by a variety of paradigms such as counting passes in the gorilla video, a line length judgement task, counting of bouncing letters on a computer screen, and being occupied on cell phones. Task difficulty is not the only aspect as similarity also plays a role, in that unexpected objects that are similar to the attendant task are less susceptible to IB than are unexpected objects that are dissimilar as evidenced by research conducted by Most et al. (2001, 2013). IB is a phenomenon that involves attentional resources that can be diminished by being very young, being older, and drinking alcohol. IB, in other words, can be induced by a reduction of or lack of resources. Much research has been conducted examining the role of WM in terms of resources and the components of capacity and executive control for goal relevant stimuli, but is stymied by conflicting results regarding the relationship between WM and IB. While IB normally involves a task with some degree of difficulty, it is not absolutely necessary to induce blindness. There was no task in the priming study performed by Slavich and Zimbardo (2013), the irrelevance blindness study performed by Eitam et al. (2013), or the disruption blindness study performed by Levin and Varakin (2004). An interesting aspect of each of the reviewed studies involves different environments. Participants watched a video, interacted with computer programs, or were observed in public. Some of these environments were more immersive such as the observational study set in the courtyard, however, some were less immersive such as the 2D bouncing letters task. One might wonder to what degree immersion can affect rates of IB, but, first, let's explore the subject of immersion.

Immersion

As previously mentioned, immersion consists of time passing without noticing, and a feeling that one is in the environment in question (Jennett et al., 2008). It can describe the extent to which one feels involved in a virtual experience, such as virtual reality and video games. Immersion possibly involves allocation of attentional resources, expectations, and cues. If one is not allocating of attentional resources in an immersive environment, then one will not be as immersed as another participant who is allocating of attentional resources. Expectations might also play a role because they are set prior to the experience in question and are based on an individual's prior experiences. Expectations can also be thought of in terms of priming, because they cause expectations to be set before an experience. Cues possibly play a role because they can help an individual to identify things such as an environment. If one notices that there are many shelves of books in a building, this person might identify that building as a library. Conversely, if one is told they are in a specific environment, one will then have expectations of the cues that comprise the specific environment.

Immersion & Video Games

Video games offer an excellent platform from which to measure immersion and can be combined with other concepts to see if there is any relationship between them. There are many variables involved in video game play such as controller naturalness and game play realism. A more natural controller is meant to make the actions in the video game feel more real to the user. In a study examining the role of controller naturalness, realism, immersion, and aggression, evidence showed that controls that were more natural and a higher level of game play realism increased the sense of immersion and, subsequently, aggression (McGloin, Farrar, & Krcmar, 2013). Four conditions were created: low realism/high controller naturalness, low realism/low controller naturalness, high realism/high controller naturalness, and high realism/low controller naturalness. A less graphically rich boxing video game was used for the low realism condition, and a more graphically rich boxing video game was used for the high realism condition; the standard console controller was used for the low controller naturalness condition; special boxing gloves for which the standard controller fit into were used for the high controller naturalness condition, because it mimicked the actions of boxing. The results revealed that the more natural the controller was, the more realistic the participants felt the game was, that more realism increased the perception of immersion, and that increased perceptions of immersion led to an increase in aggressive ideations (McGloin, Farrar, & Krcmar, 2013). This means that a more realistic gaming experience will lead to a greater sense of immersion, and that this sense of immersion would infiltrate a person's life with a quality of gameplay, which was aggression in this study. By allocating attentional resources to the game play experience and thus being more immersed, participants then exhibited the aggressive ideations from the experience of video game boxing.

In another study examining controller naturalness, results showed that controller naturalness and customization led to greater immersion (Schmierbach, Limperos, & Woolley, 2012). Researchers had participants play an auto racing game on a then current video game system with either regular hand-held controllers or a commercially available steering wheel apparatus that included gas and brake pedals. Half of these participants were able to customize the appearance of their racing car. The results indicated that participants that used the steering wheel reported the controls were natural, and led to an increase in immersion (Schmierbach, Limperos, & Woolley, 2012). The results also indicated that customization of the racing car increased identification which led to an increase in immersion (Schmierbach, Limperos, & Woolley, 2012). This agrees with the previously discussed study in that controller naturalness led to greater immersion into the game, and also showed that customization was a contributor to immersion. Here again assigning attention was possibly involved, in that participants more accurately reflected the actual act of driving a car by using a steering wheel accessory. This added the actions of steering without a traditional handheld controller and actions of feet to control acceleration and deceleration to the video game experience making it closer to the actual experience of driving a car. The added actions might require allocating more attentional resources in order to orchestrate the act of driving. In other words, one could more easily allocate attentional resources to driving because the controller was more natural.

Advancements in technology can increase the sense of immersion, as is often the purpose of that newer technology. A recent advancement in television technology has come in the form of 3DTV and requires the viewer to wear special eyewear to facilitate the 3D experience. In a study aimed at finding a connection to violence, researchers used a popular violent video game *Grand Theft Auto IV* with three conditions, 2D monitor, 2D projector, and 3D projector (Lull & Bushman, 2014). The results showed that participants reported greater levels of immersion in the 3D projector condition as opposed to either the 2D monitor or 2D projector conditions (Lull & Bushman, 2014). This means that the newer 3DTV technology facilitates a more immersive experience, and that video games that were already immersive can be aided with this newer technology in creating an even more immersive experience. This is consistent with the idea that by allocating attentional resources to the experience, the participants were more immersed. Immersion was greater in the condition with the extra dimension, and by having this extra dimension, more attentional resources were necessary for interacting with the environment.

While some advancements in technology increase immersion, not all of them will lead to greater levels of immersion. Recent trends in video game play have involved controller types in efforts to increase game play realism and have resulted in motion based controls. Williams (2013) conducted research involving video game controller type, identification with an avatar, and immersion with a boxing game for the Nintendo Wii. There were two groups based on controller type, with one group having used a Nintendo Wii remote that mimics the boxing action, and the other group having used a traditional handheld controller. The results showed that the group that used the Wii remote more closely identified with their avatars than the traditional handheld controller group (Williams K. D., 2013). The results, however, also showed that the group that used the Wii remote was not more immersed than the traditional handheld controller group (Williams K. D., 2013). This means that it might take more than the present technology regarding motion based controller types to create higher levels of immersion for some types of video games. A potential problem was that the participants expected the experience to more realistically reflect the act of boxing because of the punching action of using the Wii remote, however that punching action might not have been realistic enough to induce higher levels of immersion. In this case, the lack of realism might have caused the participants to allocate less attentional resources to the experience.

Immersion & Virtual Reality

The use of virtual reality technology in examining immersion also offers an excellent platform. In some cases, however, immersion can cause unintended consequences, and therefore implications in the use of products that induce immersion. If a person is stationary in actual reality but is moving around a virtual environment, she/he might experience motion sickness. Murata (2004) conducted an experiment to examine motion sickness and postural instability with the use of a video game system, head mounted display, and a pressure plate system. The head mounted display was used with an immersive video game on a Nintendo 64 and was played for three hours, and then a questionnaire was used to assess motion sickness. The pressure plate system was used to assess postural instability. Results showed an increase in the nausea, oculomotor disturbances, disorientation, and total severity facets of the motion sickness questionnaire after the three-hour duration and were unchanged for those in the control group (Murata, 2004). The results also showed an increase in postural instability for those playing the immersive game over those in the control group (Murata, 2004). The author indicated that this has implications for the use of virtual reality systems, in that users may need time to acclimate to actual reality before such tasks as driving a motor vehicle. It is possible that allocation of attendant resources also played a role here. Participants wore a head mounted display as opposed to just playing the game without the helmet, which closed out the stimuli of the surrounding space. This allowed for allocating additional attentional resources to the experience through the head mounted display. Distractions from the surrounding space might have a detracting effect on those allocated resources.

Immersion in a virtual world can affect how one experiences the actual world beyond symptoms of motion sickness, such as pain. Weger & Loughnan (2014) conducted experiments regarding immersion, the experience of pain in oneself, and the experience of pain in others. They found that highly immersed participants reflected the behaviors of the avatar in a video game. The researchers had participants in the highly immersive group play a non-violent first-person video game that used a virtual world and had participants in the minimally immersive group play a simple puzzle game. Following the game play, participants retrieved as many paperclips from an ice bath as possible and also evaluated pictures of people expressing pain or pleasure. The results showed that those in the highly immersive group retrieved more paperclips than those in the minimally immersive group, and those in the highly immersive group rated the expressions of pain as less intense than those in the minimally immersive group (Weger & Loughnan, 2014). The authors indicated that the participants took on the robotic behaviors and attitudes of the avatar in the video game, and thus experienced less pain in self and others. This shows some level of dissociation from self following immersion in a virtual world, and at the very least shows how the experience of pain can be modified using this virtual world. One possible explanation is that because participants were immersed to a high degree, their attendant resources remained allocated to the virtual experience. In other words, the participants were paying more attention to the earlier virtual experience rather than the current pain.

Immersion & Virtual Experience

There are degrees of virtual reality. Some VR systems use a head mounted display, but others implement other display technologies. In a study concerned with immersion and emotion, researchers found that participants in the high immersion group had more intense emotional reactions to 3D movie clips (Visch, Tan, & Molenaar, 2010). The researchers had participants in both of two immersive conditions categorize 3D movie clips by genre. The low immersion setting had just one screen in front of the viewers, and the high immersion setting had three screens that surrounded the viewers creating something of a virtual reality experience. Participants were also asked to rate emotional reactions to the 3d movie clips. Results showed that the high immersion condition rated emotions more strongly than the low immersion group (Visch, Tan, & Molenaar, 2010). This means that a more highly immersive movie experience leads to stronger emotional responses. One possible explanation is that expectations are involved in immersion. Categorizing movie clips by genre involves expectations in that genres have expected emotional aspects that make it a member of that category.

In a study comparing an actual environment to a virtual experience, Baranowski & Hecht (2014) examined viewing angle, screen size, and immersion. In the first experiment of the study, the researchers used a scale model replication of a theater and an empty black box of the same size both using a computer screen to play a movie clip, and asked participants which one they preferred. In the second experiment of the study, the researchers used a computer screen in a lit room, a computer screen in a dark room, the same scale model theater from the first experiment, and an actual theater in a between-subjects design. Their results did not show a significant effect of viewing angle on immersion in any of their experiments, but the researchers did find an effect of screen size on immersion (Baranowski & Hecht, 2014). Most importantly they found that the best predictor for immersion was whether or not the setting resembled an actual theater (Baranowski & Hecht, 2014). Immersion was the highest for the group that viewed a large screen in an actual theater and the group that viewed the smaller screen through the model theater. In other words, the interior of the model theater was enough to induce an immersive experience. This indicates that a model theater can create an immersive experience in the same way as would be found in an actual theater. This is consistent with the idea that expectations are involved in immersion. The model theater matched observer's expectations of cues that comprise what a theater looks like because it was an accurate replication.

Immersion might be increased or decreased by a variety of factors based on allocation of attentional resources, expectations, and cues. Video game controller realism, gameplay realism, and display technology all contribute to the sense of immersion likely based on allocation of attentional resources because they better reflect an experience in the actual world (McGloin et al., 2013; Schmierbach et al., 2012; Lull & Bushman, 2014). Immersion can have some unexpected outcomes such as motion sickness and increased pain tolerance, all possibly due to allocation of attendant resources (Murata, 2004; Weger & Loughnan, 2014). Controller motions and social play likely contribute to the sense of immersion based on expectations by the Williams (2013) and Cairns et al. (2013) studies respectively. Expectations regarding movie genres and what is typically present inside a movie theater (cues) can also contribute to the sense of immersion (Baranowski & Hecht, 2014; Visch et al., 2010).

The Current Study

Perhaps immersion requires attention in order for a person to interpret the input from their surroundings. If so, then immersion might involve allocation of attentional resources. This might subsequently also affect IB and memory, because both can be affected by attentional processes. As reviewed earlier, results from studies regarding video game controller realism, gameplay realism, motion sickness, and pain tolerance are consistent with the idea that allocating attentional resources can lead to differing levels of immersion (McGloin et al., 2013; Schmierbach et al., 2012; Lull & Bushman, 2014; Murata, 2004; Weger & Loughnan, 2014). If so, manipulating the level of immersion might illicit some degree of blindness to unexpected stimuli and affect memory of the experience.

Manipulation of immersion for the current study was achieved by using the same types of models that were used by Baranowski & Hecht (2014). By attempting to match but modify the Baranowski & Hecht study, we were also looking to replicate their results in terms of achieving different levels of immersion between conditions. There were, however, some differences between these two studies. The Baranowski & Hecht study only used the immersion questionnaire to compare the model against a screen of the same size in a lit or dark room in their Experiment 2. In their Experiment 1, the researchers compared the model with theater cues to a model of the same dimensions lacking in those cues. They did not use the immersion questionnaire in their Experiment 1, but rather asked participants to "stand in front of each setup for a while; then decide where you get more immersed in the movie" (p 1063). In the current study, the models were compared based on the immersion questionnaire, and it was expected that the immersion ratings would translate to the questionnaire.

This comparison of just the models is rooted in the desire to have an IB paradigm that can be used with either model to examine whether immersive environments have an effect on susceptibility to IB. The IB paradigm needed to be exactly the same regardless of condition, and that would not be achievable using a same sized computer screen in a lit or dark room. The added IB paradigm apparatus was produced by Kre8Now Makerspace, a small engineering business located in Lexington, KY, that moved an unexpected stimulus across the stage in front of the movie screen in all conditions. Another question we were interested in answering was whether different levels of unexpected stimulus realism would have an effect on susceptibility to IB. To answer this question, two different unexpected stimuli were used; one that matches a theater environment and one that does not match a theater environment.

Altogether, the current study is a 2 x 2 between-subjects design with two factors; theater type (immersion) and stimulus type. For the IB paradigm in the current study, there was not a traditional task as normally found in most IB studies. However, as in the previously reviewed studies, a traditional task is not necessary to induce blindness (Slavich & Zimbardo, 2013; Eitam et al., 2013; Levin & Varakin, 2004). In this case, simply watching the movie clip can be considered the task. A memory quiz for the movie clip content was created to both verify that participants were following instruction, and test whether or not immersive environments have an effect on memory. The same movie clip as used by Baranowski & Hecht (2014) was utilized in the current study.

CHAPTER 3

Experiment 1

For Experiment 1, the models, stimuli, and other materials were used to answer the afore mentioned questions regarding levels of immersion and stimulus realism, IB, and memory. The decision to stop at N = 31 was made due to reports of sound and vibration from participants.

Method

Participants

Participants were all from the Eastern Kentucky University (EKU) community in Richmond, Kentucky. For N = 31, there were 14 males and 17 females ranging in age from 18 to 29 years (M = 20.52, SD = 2.36). Participants were randomly assigned to one of four groups: realistic with high stimulus relevance (N = 7), realistic with low stimulus relevance (N = 10), haphazard with high stimulus relevance (N = 5), or haphazard with low stimulus relevance (N = 10). Participants were tested individually.

Materials & Procedure

The participants arrived at the lab individually and were each given their informed consent paperwork. The participant was seated facing the model theater, or control condition model, backed up to the computer monitor, [1](Figure 9). They were instructed to hold their head centered in the opening of the back of the model looking in

[1] All figures are presented in appendices at end of thesis.

at the monitor at the other end, (Figure 10). There was a black sheet that was draped over the back of the model to keep out any unwanted light, and the lights in the room were turned off. The participant was only able to see the screen and the dimly lit interior of either condition, (Figure 11). Audio from the movie clip was played through the headphones, which also served to block out any unwanted sounds from the ambient environment. The 11-minute 10-second clip of *Gulliver's Travels* (Davis, Goodman, Cooley, Black, & Letterman, 2010) was played, and, 15 seconds in, the lights slowly dimmed until off. At the 5-minute mark, one or the other unexpected stimulus emerged from behind the left curtain and moved to the other side of the stage. The stimulus was not in view while it was at either side of the stage. The unexpected stimulus took 7 seconds to cross the stage. With 15 seconds left in the movie clip, the lights slowly turned back on. The lights in the room were then turned back on and, at the end, the participant was asked to fill out the questionnaire in PsychoPy. Debriefing information was provided after the experiment concluded.

Physical materials for the high immersion (realistic) conditions included a PC computer, two monitors, a model replication of a movie theater (2' x 2' x 2'), a black sheet to block out background light, and headphones for audio. In order to differentiate the high immersion group from the low immersion group, realistic theater accoutrements were used that match the expectations one might have of an actual full modern movie theater including curtains, seats, wall sconces, wallpaper, wainscoting, and patrons. The patrons were 3D printed and placed in some of the seats, (Figure 1). Physical materials for the low immersion (haphazard) conditions included the same PC computer, a copy of the model replication of a movie theater (2' x 2' x 2'), a black sheet to block out background light, and the same Sony headphones for sound. The low immersion condition model contained all the same materials as the high immersion condition model, but those materials were distributed in a haphazard manner which did not resemble an actual full modern movie theater, (Figure 2). Both models contained the same wall sconces in order to control for lighting between conditions. Both the high and low immersion condition models backed up to a computer monitor, which served as the movie theater screen. Another computer monitor was used by the experimenters in order to observe progress during the movie clip and to stop the movie at the end of the eleven-minute clip.

There was an IB paradigm apparatus that could be used with either immersion condition which moved an object across the stage in front of the computer monitor. This was facilitated by an Arduino computer, 3D printer parts, a motor, and wiring all housed underneath the stage area inside a box, (Figure 3). This stage area box was a stand-alone unit which could be inserted into either the realistic or haphazard conditions, (Figure 4). The Arduino computer inside the apparatus controlled the lighting and the timing of the unexpected stimuli. There were two different unexpected stimuli, one to maintain the illusion of the movie theater and one to break the illusion of the movie theater. The unexpected stimulus that maintained the illusion of a movie theater was a standing version of a 3D printed movie theater patron, (Figure 5). The movie patron was 2.5cm, at its widest, and 9cm tall. The unexpected stimulus that broke the illusion of a movie theater was a bolt, (Figure 6). The bolt was 1cm by 7cm long (tall). The unexpected stimuli were on posts that could be inserted into a wood block attached to a platform that is moved by the motor from one side of the stage to the other, (Figures 7 and 8). The first eleven minutes of the movie *Gulliver's Travels* (Davis, Goodman, Cooley, Black, & Letterman, 2010) was played on the PC computer monitors.

A questionnaire was constructed in PsychoPy 1.86 (Pierce, 2007), a psychology research computer program. This questionnaire contained all measurements regarding the experiment, which includes the same set of immersion questions as used by the Baranowski & Hecht (2014) study. See appendix for all items on the questionnaire. First in the questionnaire were two questions about IB to assess the noticing of unexpected stimuli. After the IB questions, participants completed the immersion questions. After the immersion questions, ten multiple choice questions were presented regarding memory for events in the movie clip. Lastly, there were two demographic questions of age and gender.

Results

One of the immersion items did not seem to be entirely relevant, "How relaxing or exciting was the experience?" The content of the movie clip used in the Baranowski & Hecht study does not involve much excitement, and the experience of watching a movie in a theater might not be equated with excitement to the participant because it is a subjective experience. To address this issue, two versions of results are presented. The versions differ based on the exclusion of the immersion item in question, and are referred to as the reduced and full questionnaires.

Reduced Questionnaire

A two-way ANOVA was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable immersion. The high immersion condition scored higher than the low immersion condition, $F(1,27) = 4.89$, $p = .036$, partial $\eta^2 = .15$. Stimulus type did not have a significant effect, $F(1,27) = .36$, $p = .556$, partial $\eta^2 = .01$. There was no evidence of an interaction effect, $F(1,27) = .031$, $p = .862$, partial $\eta^2 = .001$. See table 1 for this data.

Table 1 Means and (Standard Deviations) for the reduced version of the questionnaire in Experiment 1

	Bolt	Movie Patron
Realistic	5.58 (.87)	5.80 (.35)
Haphazard	5.00 (.95)	5.12 (.70)

Full Questionnaire

The same two-way ANOVA was performed for the full questionnaire. Theater type did not have a significant effect on immersion, $F(1,27) = 3.52$, $p = .072$, partial $\eta^2 = .12$. Stimulus type did not have a significant effect on immersion, $F(1,27) = .33$, $p = .573$, partial $\eta^2 = .01$. There was no evidence of an interaction effect, $F(1,27) = .00$, $p = .994$, partial $\eta^2 = .00$. See table 2 for this data.

Table 2 Means and (Standard Deviations) for the full version of the questionnaire in Experiment 1

	Bolt	Movie Patron
Realistic	5.63 (.92)	5.79 (.34)
Haphazard	5.10 (.89)	5.27 (.58)

Memory

A two-way ANOVA analysis was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable memory. Theater type did not have a significant effect, $F(1,27) = .157$, $p = .695$, $\eta^2 = .01$. Stimulus type did not have a significant effect, $F(1,27) = 1.409$, $p = .246$, $\eta^2 = .05$. There was no evidence of an interaction effect, $F(1,27) = 2.260$, $p = .144$, $\eta^2 = .08$. See table 3 for this data.

Table 3 Means and (Standard Deviations) for the memory quiz in Experiment 1

	Bolt	Movie Patron
Realistic	.89 (.09)	.90 (.00)
Haphazard	.92 (.09)	.84 (.13)

IB

A direct logistic regression analysis was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable IB. There was an interaction variable as well to assess the interaction of theater type and stimulus type. Correctly noticing the unexpected stimulus was the outcome variable. The logistic regression model was not better than the constant only model in predicting the noticing of the unexpected stimulus, ($\chi^2 = 4.287$, df = 3, p = .232). Theater type did not predict the odds of noticing the unexpected stimulus, ($\beta = -9.46$, Wald $\chi^2 = 0.000$, p = .999). While it appeared that there was more blindness for the bolt, stimulus type did not predict the odds of noticing the unexpected stimulus, ($\beta = 10.895$, Wald $\chi^2 = 0.000$, p = .999). There was no evidence for an interaction, ($\beta = -9.797$, Wald $\chi^2 = 0.000$, p = .999). 77.4% of participants noticed the unexpected stimuli. See table 4 for this data.

Table 4 Percentage scores by condition for IB in Experiment 1

	Bolt	Movie Patron
Realistic	30%	14.3%
Haphazard	33%	0

Discussion

The results using the reduced immersion questionnaire replicated previous research conducted by Baranowski & Hecht (2014). The realistic model induced higher levels of immersion than the haphazard model. This matches the Baranowski & Hecht study because their participants rated the model with theater cues as being the more immersive environment through which to watch the movie clip. However, when the full immersion questionnaire was analyzed, the results became non-significant. An unexpected aspect of the results was that everyone was highly immersed regardless of condition. This was not true of the Baranowski & Hecht study. Results showed that theater type and stimulus type did not have an effect on memory. IB was about the same in both conditions, and neither theater type nor stimulus type had an effect on IB. With the reduced immersion questionnaire, these results suggest that immersive environments have their effect on the human mind without affecting memory. With the full questionnaire, the results show no interaction between immersive environments, IB, and memory.

There were some limitations in Experiment 1 that were addressed by Experiment 2. The motor inside the apparatus made too much sound and vibration which may have alerted the participants to the unexpected stimulus moving across the stage. The timing of the movement of the stimulus across the stage at the 5-minute mark occurred at a very quiet moment during the movie clip. With 5 minutes left in the experience, the participants might have merely forgotten that they had seen anything by the time they were asked. Also, the lights came back on too early in the movie clip during a moment that provided one of the answers to the multiple-choice questions in the memory quiz. There were only 31 participants, and a 2-way ANOVA power analyses called for 128 participants for decent power (.8) to detect a medium effect (.25).

CHAPTER 4

Experiment 2

The methods used in Experiment 2 were the same as were used in Experiment 1 except as explained.

Method

The sound and vibration issues were reduced with the addition of sound absorbing material inside the housing of the apparatus. The housing was otherwise acting as a sound amplifier, much like an acoustic guitar. The timing of the unexpected stimulus was changed to a later moment in the movie (at 6:36) in which the main character was interacting with a guitar play-along based video game that provided a much louder moment for the stimulus to move across the stage. Sound pressure level readings were taken; the motor itself was 76.4 db, the selected scene was 71.4 decibels (db), and other moments in the movie clip were within 55 – 60 db. With the use of the headphones, test runs showed that the motor's sound was masked by the soundtrack in the movie. The timing of the lights was also changed so that they came back on 30 seconds later, thus leaving the participant immersed in the experience during the moment that provided one of the answers to the multiple-choice questions in the memory quiz. The hypotheses were the same as in Experiment 1.

Participants

Participants were recruited entirely from the Eastern Kentucky University (EKU) community in Richmond, Kentucky. For N = 168, there were 53 males and 113 females ranging in age from 15 to 50 years (M = 20.02, SD = 3.91). One participant did not report gender, and another did not report either gender or age. Participants were randomly assigned to one of four of the same groups as in experiment 1, and were tested individually.

Materials & Procedure

The same questionnaire was used from experiment one. Physical materials were the same, except for changes made to the control condition. It was decided to make the control condition better resemble the control condition from the Baranowski et al. (2014) experiment by covering some of the similar materials with heavy black construction paper. This was intended to make the control condition less immersive. The same updated IB apparatus was used along with the same stimuli. The same procedure used in experiment one was used in experiment two, with the changes made to the timing of the stimuli and lights. The same movie clip was used as well.

Results

Results are presented the same way as Experiment 1. Both versions of the immersion questionnaire were analyzed, and Cronbach's alpha data were acquired. Cronbach's alpha for the full 6 questions was 0.825. Cronbach's alpha for the reduced questionnaire was 0.799.

Reduced Questionnaire

A two-way ANOVA was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable immersion.

Theater type did not have a significant effect, $F(1,164) = 2.98$, $p = .086$, partial $\eta^2 = .018$. Stimulus type did not have a significant effect, $F(1,164) = .001$, $p = .975$, partial $\eta^2 = .00$. There was no evidence of an interaction effect, $F(1,164) = .025$, $p = .875$, partial $\eta^2 = .00$. See table 5 for this data.

Table 5 Means and (Standard Deviations) for the reduced version of the questionnaire in Experiment 2

	Bolt	Movie Patron
Realistic	5.24 (.96)	5.23 (.95)
Haphazard	5.46 (.62)	5.48 (.88)

Full Questionnaire

The same two-way ANOVA was performed for the full questionnaire. Theater type did not have a significant effect, $F(1,164) = 2.62$, $p = .107$, partial $\eta^2 = .016$. Stimulus type did not have a significant effect, $F(1,164) = .001$, $p = .978$, partial $\eta^2 = .00$. There was no evidence of an interaction effect, $F(1,164) = .01$, $p = .940$, partial $\eta^2 = .00$. See table 6 for this data.

Table 6 Means and (Standard Deviations) for the full version of the questionnaire in Experiment 2

	Bolt	Movie Patron
Realistic	5.23 (.98)	5.24 (.93)
Haphazard	5.46 (.64)	5.46 (.89)

Memory

A two-way ANOVA was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable memory. Theater type did not have a significant effect, $F(1,164) = .08$, $p = .779$, $\eta^2 = .00$. Stimulus type did not have a significant effect, $F(1,164) = .05$, $p = .829$, $\eta^2 = .00$. There was no evidence of an interaction effect, $F(1,164) = 1.411$, $p = .237$, $\eta^2 = .01$. See table 7 for this data.

Table 7 Means and (Standard Deviations) for the memory quiz in Experiment 2

	Bolt	Movie Patron
Realistic	.89 (.08)	.90 (.08)
Haphazard	.91 (.09)	.90 (.09)

IB

A direct logistic regression analysis was performed to assess the effects of the independent variables of theater type and stimulus type on the dependent variable IB.

Correctly noticing the unexpected stimulus was the outcome variable. The logistic regression model was not better than the constant only model in predicting the noticing of the unexpected stimulus, ($\chi^2 = .08$, df = 3, p = .994). Theater type did not predict the odds of noticing the unexpected stimulus, ($\beta = -.11$, Wald $\chi^2 = 0.05$, p = .898). Stimulus type did not predict the odds of noticing the unexpected stimulus, ($\beta = .01$, Wald $\chi^2 = 0.00$, p = 1.006). There was no evidence for an interaction, ($\beta = -.195$, Wald $\chi^2 = 0.03$, p = .853). 87.5% of participants noticed the unexpected stimuli. See table 8 for this data.

Table 8 Means and (Standard Deviations) for memory scores in Experiment 2

	Bolt	Movie Patron
Realistic	13.46%	12.5%
Haphazard	11.76%	11.9%

Discussion

Regardless of the version of immersion questionnaire used, there was no effect of theater and stimulus types on immersion. The results from the Baranowski & Hecht (2014) study were not replicated in experiment 2. However, the trend was the same as in Experiment 1, because when the reduced version of the immersion questionnaire was used, the results approached significance. Everyone was immersed in this experiment as well as in Experiment 1, however, in Experiment 2, participants in the haphazard condition were more immersed than the participants in the realistic condition. In agreement with Experiment 1, there was no effect of theater and stimulus types on memory. Also in agreement with Experiment 1, IB was about the same in both conditions, and there was no effect of theater type or stimulus on IB.

CHAPTER 5

General Discussion

In Experiment 1, evidence showed that manipulating the environment (theater type) had an effect on immersion with the reduced questionnaire. This was not true for the full questionnaire. Stimulus type had no effect regardless of immersion questionnaire version. Neither theater type nor stimulus type had effects on memory or IB. In Experiment 2, neither theater type nor stimulus type had an effect on immersion, memory, or IB.

In looking at the data, there was a trend towards results that would indicate that manipulating immersion can affect rates of IB in both experiments. The data regarding immersion became significant in Experiment 1 and approached significance in Experiment 2 when the as previously decided irrelevant question was dropped. This suggested that dropping the question was the correct action. However, the Cronbach's alpha data did not support this course of action. The Cronbach's alpha data showed that the full version of the questionnaire was the more reliable version.

As evidenced in both experiments in the current study, all participants were highly immersed regardless of condition. The theater cues of the realistic condition elicited high levels of immersion, but the haphazard condition also elicited high levels of immersion, though not as high. In Experiment 2, not only were all participants immersed, those in the haphazard conditions were more immersed than those in the realistic condition. Both model conditions proved to be very immersive environments through which to watch a movie clip.

Why did the immersion results not replicate from the previous study by Baranowski & Hecht? The alpha data suggests that the full version of the immersion questionnaire as used by Baranowski & Hecht is the more reliable version. We should not have to drop a question in order to replicate a previous study. It is best to replicate that study in every way possible. The issue is complicated because the conditions in the current study were not exact replicas of the conditions used in the Baranowski & Hecht study. As previously discussed, the researchers did not measure immersion the same way in both of their experiments, and did not do a direct comparison between model conditions using the immersion questionnaire. This makes saying whether or not we replicated a prior study very difficult, however we did expect the comparison based rating of immersion to translate to the immersion questionnaire. Other differences include that both model conditions in the current study had working wall sconces whereas the models used in the Baranowski & Hecht study did not have any lighting. The control condition (haphazard) in the current study included colors, materials, and lighting levels from the realistic condition, whereas the control condition in Experiment 1 of the Baranowski & Hecht study was completely blacked out. This is an important area to consider for why the results did not replicate from a previous study. Future research might be able to more closely match the original study in order to see if there is truly an effect of immersion present between the conditions. Results from the current study did not appear to support the idea that environments designed to be immersive can affect attention or memory. Results from the current study regarding attention were inconclusive because everyone was immersed to a high degree, and, in the second experiment, participants in the haphazard condition were more immersed than the participants in the realistic condition. Results from the current study regarding memory are inconclusive because of an apparent ceiling effect. All participants scored very high on the memory quiz. It might be easy to think that attention and memory can be affected by immersive environments, but more research is needed in order to explore this further.

While there was no effect for either theater type or stimulus type on IB in either experiment, blindness for unexpected objects did occur. 22.6% of participants missed the stimuli in Experiment 1, and 12.5% missed the stimuli in Experiment 2. Neither are very large amounts, however blindness in the current study was achieved in the absence of a traditional task such as counting basketball passes and tracking moving objects on a computer screen. Paying attention to the movie clip was more than likely to happen regardless of being instructed to do so. This, if anything, was the task, and the experiment still induced blindness. As reviewed earlier, blindness was induced for a close-in-proximity concentric ring of color in the Eitam et al., (2013) study and for disruptions in short videos in the Levin & Varakin (2004) study both in the absence of a task. Evidence gained from the current study also supports this idea that a task is not needed to induce blindness for unexpected objects.

While the sound and vibration levels were thought to be taken care of from Experiment 1, one participant still reported both hearing and feeling the vibration generated by the apparatus. This might have served to alert all of the participants that noticed the unexpected stimulus to the presence of that stimulus. Two participants reported that the lights flickered inside the model. There might have been a malfunction in the presentation of the lights at some moment in the movie clip thus having disrupted the entire experience. It is unknown as to what extent this malfunction occurred. As previously mentioned, the conditions were not exactly the same in the current study as in the Baranowski & Hecht study. The principle investigator was the only person running participants in Experiment 1, however, in Experiment 2, two graduate assistants ran participants. The principle investigator was the one that was most informed on the subject, and this knowledge might have had an effect on the results of Experiment 1 versus Experiment 2 in terms of how the experiment and immersion were explained to the participant. Another limitation to consider is that the Baranowski & Hecht study used participants from Mainz, Germany whereas participants for the current study were from the United States. Perhaps there are subtle differences between the two cultures that might affect how objects are perceived and how attention is applied to environments.

Future directions include remedying the differences between the current study and the Baranowski & Hecht study. This could be done by comparing the models based on participants interpretation of immersion in within-subjects design or it could be done by adding a condition using only a same size computer screen in a room. Both of these options present a major complication to examining immersion and IB. IB is very difficult to study in a within-subjects design. Once a participant sees an unexpected object, it is no longer unexpected. If a room is used instead of the model, how would the IB paradigm be included? Some other type of paradigm would need to be considered.

CHAPTER 6

Conclusion

Immersive environments through which to view a movie can be created with the use of models and computer monitors. As was evidenced in the current study, however it may be difficult to create varying levels of immersion. The current study was inconclusive because everyone was immersed and scored very high on the memory quiz. This led to inconclusive results regarding the relationship between IB, immersion, and memory. Blindness, though, for unexpected stimuli can occur, and can do so without a task. This adds to growing evidence that a task is not necessary to induce blindness for unexpected stimuli. Immersion results did not replicate the Baranowski & Hecht study, as those researchers found both high and low levels of immersion.

List of References

1. Baranowski, A. M., & Hecht, H. (2014). The big picture: Effects of surround on immersion and size. *Perception, 43*, 1061-1070.

2. Bleckley, M. K., Foster, J. L., & Engle, R. W. (2015). Working memory capacity accounts for the ability to switch between object-based and location-based allocation of visual attention. *Memory and Cognition, 43*(3), 379-388.

3. Bredemeier, K., & Simons, D. J. (2012). Working memory and inattentional blindness. *Psychon Bull Review, 19*, 239-244.

4. Clifasefi, S. L., Takarangi, M. K., & Bergman, J. S. (2006). Blind Drunk: The effects of alcohol on inattentional blindness. *Applied Cognitive Psychology, 20*, 697-704.

5. Eitam, B., Yeshurun, Y., & Hassan, K. (2013). Blinded by irrelevance: pure irrelevance induced "blindness". *Journal of Experimental Psychology, 39*(3), 611-615.

6. Fernandes, M. A., & Moscovitch, M. (2000). Divided attention and memory: evidence of substantial interference effects at retreival and encoding. *Journal of Experimental Psychology: General, 129*(2), 155-176.

7. Fougnie, D., & Marois, R. (2007). Executive working memory load induces inattentional blindness. *Psychonomic Bulltin & Review, 14*(1), 142-147.

8. Graham, E. R., & Burke, D. M. (2011). Aging increases inattentional blindness to the gorilla in our midst. *Psychology and Aging, 26*(1), 162-166.

9. Hyman Jr., I. E., Boss, S. M., Wise, B. M., McKenzie, K. E., & Caggiano, J. M. (2010). Did you see the unicycling clown? Inattentional blindness while walking and talking on a cell phone. *Applied Cognitive Psychology, 24*, 597-607.

10. Jennett, C., Cox, A. L., Cairns, P., Dhoparee, S., Epps, A., Tijs, T., & Walton, A. (2008). Measuring and defining the experience of immersion in games. *International Journal of Human-Computer Studies, 66*, 641-661.

11. Kreitz, C., Furley, P., Memmert, D., & Simons, D. J. (2015). Inattentional blindness and individual differences in cognitive abilities. *PLoS ONE, 10*(8), e0134675. doi:10.1371/journal.pone.0134675.

12. Levin, D. T., & Varakin, D. A. (2004). No pause for a brief disruption: Failures of visual awareness during ongoing events. *Consciouness and Cognition, 13*, 363-372.

13. Loaiza, V. M., McCabe, D. P., Youngblood, J. L., Rose, N. S., & Myerson, J. (2011). The influence of levels of processing on recall from working memory and delayed recall tasks. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(5), 1258-1263.

14. Lull, R. B., & Bushman, B. J. (2014). Immersed in violence: presence mediates the effect of 3D violent video gameplay on angry feelings. *Psychology of Popular Media Culture*, http://dx.doi.org/10.1037/ppm0000062.

15. MacDonald, J. S., & Lavie, N. (2008). Load induced blindness. *Journal of Experimental Psychology: Human Perception and Performance, 34*(5), 1078-1091.

16. Mack, A., & Rock, I. (1998). Chapter One. In *Inattentional Blindness.* Cambridge: MIT Press.

17. McGloin, R., Farrar, K., & Krcmar, M. (2013). Video games, immersion, and cognitive aggression: does the controller matter? *Media Psychology, 16*, 65-87.

18. Most, S. B. (2013). Setting sights higher: category-level attentional set modulates sustained inattentional blindness. *Psychological Research, 77*, 139-146.

19. Most, S. B., Simons, D. J., Scholl, B. J., Jimenez, R., Clifford, E., & Chabris, C. F. (2001). How not to be seen: The contribution of similarity and selective ignoring to sustained inattentional blindness. *Psychological Science, 12*(1), 9-17.

20. Murata, A. (2004). Effects of duration of immersion in a virtual reality environment on postural stability. *International Journal of Human Computer Interaction, 17*(4), 463-477.

21. Pierce, J. (2007). PsychoPy -- Psychophysics software in Python. *Journal of Nueroscience Methods, 162*(1 - 2), 8 - 13.

22. Remmington, A., Cartwright-Finch, U., & Lavie, N. (2014). I can see clearly now: the effects of age and perceptual load on inattentional blindness. *Frontiers in Human Neuroscience, 8*, 1-11.

23. Richards, A., Hannon, E. M., & Derakshan, N. (2010). Predicting and manipulating the incidence of inattentional blindness. *Psychological Research, 74*, 513-523.

24. Richards, A., Hannon, E. M., Vohra, S. I., & Golan, J. (2014). Tales of the unexpected: attentional awareness, goal relevance, and prior exposure to an unexpected change. *Psychology of Consciousness: Theory, Research, and Practice, 1*(3), 284-291.

25. Robillard, G., Bouchard, S., Fournier, T., & Renaud, P. (2003). Anxiety and presence during VR immersion: a comparative study of the reactions of phobic and non-phobic participants in therapeutic virtual environments derived from computer games. *Cyberpsychology and Behavior, 6*(5), 467-476.

26. Rose, N. S., & Craik, F. I. (2012). A processing approach to the working memory/long-term memory distinction: Evidence from the levels of processing span task. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38*(4), 1019-1029.

27. Schmierbach, M., Limperos, A. M., & Woolley, J. K. (2012). Feeling the need for (personalized) speed: how natural controls and customization contribute to enjoyment of a racing game through enhanced immersion. *Cyberpsychology, Behavior, and Social Networking, 15*(7), 364-369.

28. Seegmiller, J. K., Watson, J. M., & Strayer, D. L. (2011). Individual differences in susceptibility to inattentional blindness. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37*(3), 785-791.

29. Simons, D. J. (2010). Monkeying around with the gorillas in our midst: familiarity with an inattentional-blindness task does not improve the detection of unexpected events. *i-Perception, 1*, 3-6.

30. Simons, D. J., & Chabris, C. F. (1999). Gorillas in our midst: Sustained inattentional blindness for dynamic events. *Perception, 28*, 1059-1074.

31. Slavich, G. M., & Zimbardo, P. G. (2013). Out of mind, out of sight: unexpected scene elements frequently go unnoticed until primed. *Current Psychology, 32*, 301-317.

32. Todd, J. J., Fougnie, D., & Marois, R. (2005). Visual short-term memory load suppresses temporo-parietal junction activity and induces inattentional blindness. *Psychological Science, 16*(12), 965-972.

33. Troyer, A. K., & Craik, F. I. (2000). The effect of divided attention on memory for items and their context. *Canadian Journal of Experimental Psychology, 3*, 161-170.

34. Varakin, D. A., & Hale, J. (2014). Intentional memory instructions direct attention but do not enhance visual memory. *SAGE Open*, 1-8.

35. Visch, V. T., Tan, E. S., & Molenaar, D. (2010). The emotional and cognitive effect of immersion in film viewing. *Cognition and Emotion, 24*(8), 1439-1445.

36. Weger, U. W., & Loughnan, S. (2014). Virtually numbed: immersive video gaming alters real-life experience. *Psychonomics Bulliten Review, 21*, 562-565.

37. Weibel, D., Wissmath, B., & Mast, F. W. (2010). Immersion in mediated environments: the role of personality traits. *Cyberpsychology, Behavior, and Social Networking, 13*(3), 251-256.

38. Williams, C. C. (2010). Incidental and intentional visual memory: What memories are and are not affected by encoding tasks. *Visual Cognition, 18*(9), 1348-1367.

39. Williams, K. D. (2013). The effects of video game controls on hostility, identification, and presence. *Mass Communication and Society, 16*, 26-48.

APPENDICES

APPENDIX A: Scales used in the Questionnaire

APPENDIX A: Scales used in the Questionnaire

As follows are all the scales used in the questionnaire ion the order presented to the participant.

IB

Did you see anything unexpected during the viewing of the movie?

If so, please use the keyboard to describe anything you noticed in detail.

Immersion [not at all—very much (7 points)]

To what extent did you feel mentally immersed in the experience?

How involving was the experience?

How completely were your senses engaged?

To what extent did you experience a sensation of reality?

How relaxing or exciting was the experience?

How engaging was the story?

Movie Quiz

What time did the alarm clock say at the beginning of the movie clip?

What city was the movie clip set in?

In what department does Gulliver work?

What style of video game was Gulliver playing?

What color was Jack Black's shirt?

What was the main character doing in the first work scene?

What was his crush's position at work?

What happened to the new employee?

What happened when the main character went to ask his crush out on a date?

What does he do to finish the writing sample on time?

Demographic Questions

How old are you?

What is your gender?

APPENDIX B: The Memory Quiz

APPENDIX B: The Memory Quiz

Correct answers for the memory quiz:

He plagiarized from travel brochures.

New York

Guitar Play-along

He got a promotion.

talking to a new employee

Travel editor

Mailroom

He took a travel assignment.

Grey

7am

Incorrect answers for the memory quiz:

He paid someone else to write it for him. instead.	He got drunk instead.	He fell asleep
L.A.	Denver	Chicago
Role Playing	Car Racing	First Person Shooter
He got fired.	He broke his leg.	He got into a fight.
drinking coffee briefcase	typing on a computer	putting files into his
Reporter	Janitor	Mailroom clerk
Reporter	Editorial Staff	Janitorial

He passed out.	His pants fell down.	She accepted.
Black	White	Blue
6am	9am	8am

APPENDIX C: Figures

APPENDIX C: Figures

Figure 1. Realistic condition

Figure 2. Haphazard condition

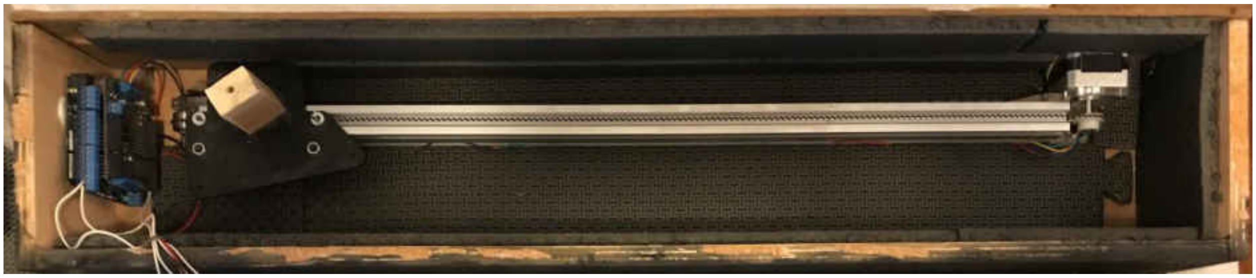

Figure 3. Overhead interior of the IB mechanism

Figure 4. Angled overhead interior with lid of IB mechanism

Figure 5. An unexpected stimulus; The patron

Figure 6. An unexpected stimulus; The bolt

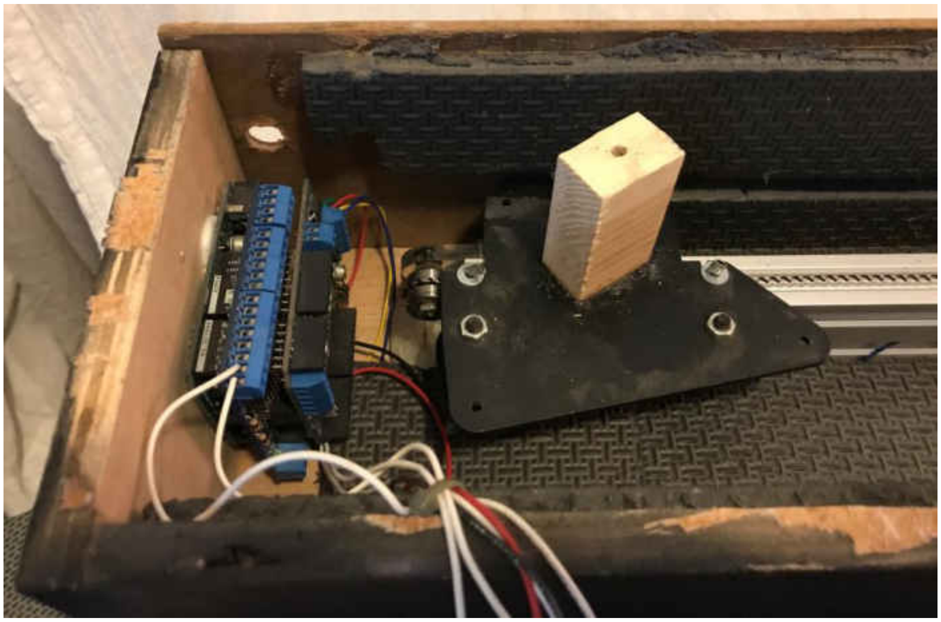

Figure 7. Close up of the Arduino computer within the IB mechanism

Figure 8. Front of IB mechanism with an unexpected stimulus

Figure 9. Participant interacting with the model from an angle

Figure 10. Participant interacting with the model from the side

Figure 11. Participant's view of the interior with surrounding lights off