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DEPARTMENT OF PSYCHOLOGY

THE EFFECTS OF VIRTUAL REALITY IMMERSION ON LEVEL OF SUBJECT INTEREST: COMPARING DESKTOP AND HEAD-MOUNTED DISPLAY CONDITIONS

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ABSTRACT

Over the past year, the popularity of Virtual Reality (VR) has exploded. The VR industry netted over 7 billion dollars in 2013, which was a 4 billion dollar increase from 2012 (Plunkett, 2014). Google and Facebook each invested over 2 billion in Virtual reality in 2013 (Gelles, 2014). New Head-Mounted Display (HMD) systems, which provide realistic VR experiences, are lightweight, portable, and user-friendly, dropping in cost the past few years (Cakmakci, 2006; Rolland, 2000). Multiple studies have concluded specific benefits of HMD VR technology including perceptions of realism, involvement of participants, and learning outcomes (Abulrub , 2013; Bayarri, 1996; Fast, 2004; Li, 2005; Santos, 2009; Sielhorst, 2004;Stone, 2013). The current study investigated the effects of HMD systems on participant's interest. Change in participant interest and immersion were measured in the current study. Analyses revealed that immersion through VR did not did not change interest level significantly (mean=5.15, SD= 1.084, p=.73). However, the results showed that HMD systems were significantly more immersive than a desktop condition (mean=3.83, SD= 1.46, p=.04).

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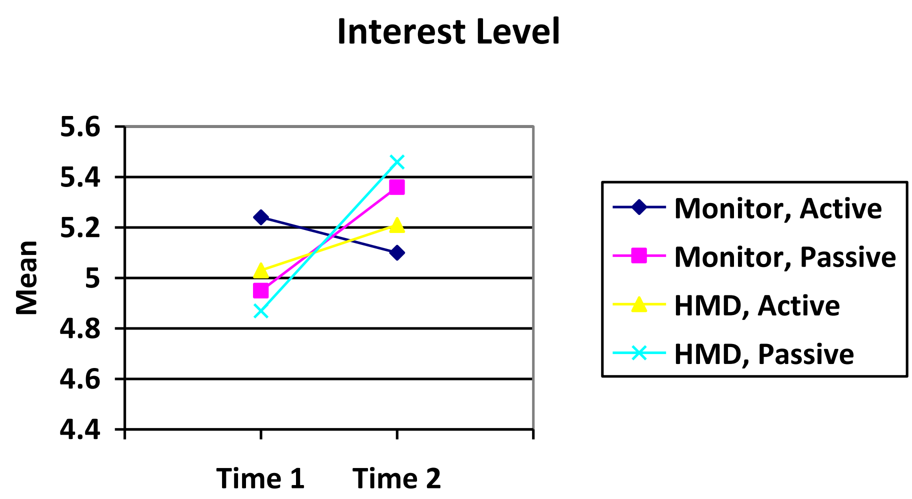
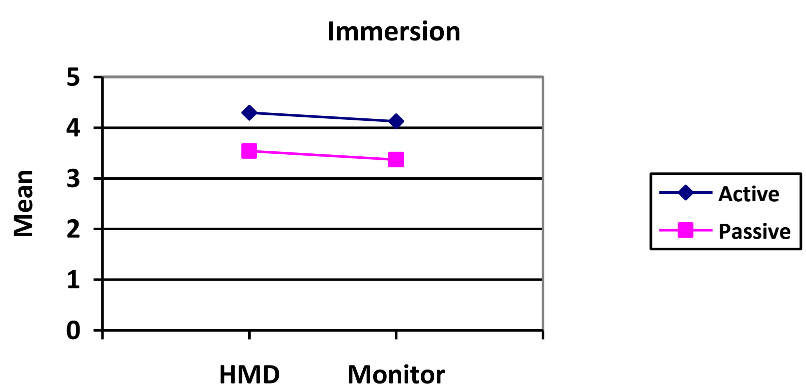

Interest Level
Mean
5.6
5.4
5.2
5
4.8
4.6
4.4
Time 1
Time 2
Monitor, Active
Monitor, Passive
HMD, Active
HMD, Passive


Immersion
Mean
5
4
3
2
1
0
HMD
Monitor
Active
Passive

TABLES

Gender	Males = 30	Females = 60
Ethnicity	Asian	12
	African American	7
	Caucasian	70
	Other	1
High School GPA	3.73	SD= .35
College GPA	3.23	SD= .39

Condition	**Number of Subjects**	**Mean**	**Standard Deviations**
Monitor, Active	45	5.150	1.184
Monitor, Passive	45	5.184	1.199
HMD, Active	46	5.182	1.086
HMD Passive	44	5.182	1.029

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Chapter 1

Introduction

Since the first Head-Mounted Display (HMD) systems arrived on the scene in the late 1980's, virtual immersion technology has found multiple applications for training and classroom educational settings. Such uses include aeronautical, medical, educational, and design training simulators (Abulrub , 2013; Bayarri, 1996; Li, 2005; Stone, 2013). Due to the increasing popularity, major advancements in virtual reality (VR) technology have been made, thus making HMD systems low-cost, user-friendly, and lightweight (Cakmakci, 2006; Rolland, 2000).

Today, VR technology allows for complete immersion in a 3-D environment (Baños , 2004; Brown, 2007). Various studies support that HMD's are effective for specific areas of training (Chua, 2003; Fast, 2004; Santos, 2009; Sielhorst, 2004). However, few studies have addressed the potential of HMD systems for influencing employee's interest in a subject. Kraiger (1993) found that those with a greater level of interest become more committed to the training. Stronger commitment increased motivation to process new material related to the training. In contrast, those with a menial interest level were passive or noncommittal, which drastically decreased learning outcomes. Therefore, influencing subject interest through VR could increase training effectiveness.

In 2010, businesses in the United States spent $171.5 billion on training and development. This spending funded training centers, development staff, and continued education. Virtual environments hold vast potential for increasing training efficiency and lowering these training costs (Berry, 2008). Now, instead of companies spending millions of dollars developing and executing real world training environments, their employees could use HMD's to enter a simulated environment that closely replicates the real world. Although virtual environments are initially tedious to program, once created, trainees could simply attach a HMD set to their laptop and commence training (Sherman, 2002). Furthermore, HMD systems could result in large corporate expenditure savings (Berry, 2008). If a virtual environment can replicate a real-world training scenario then corporations would not need to fund and staff a conventional training center. Corporations set aside large sums of money to fund staff to travel and receive professional development (Cohen, 2010).With a HMD, no travel is necessary. Due to recent technological development, HMD systems are now as mobile as a laptop and compatible with most computers (Ottosson, 2002).

HMD technology also offers simple user-friendly hardware, which is ideal for advanced robust training programs (Ogasawara, 2004). However, multiple VR mediums exist. First, the CAVE, which is a room consisting of multiple projectors to create a 3-D environment (Burdea, 2003). Costing upwards of $100,000 per system, these virtual environments are technologically complex and expensive (DeFanti, 2009). Furthermore, they are not portable. Second, many virtual reality systems, such as simple online tutorials, utilize a computer monitor (Burdea, 2003). Users feel like they are watching the training as opposed to being present at the training because these systems lack immersive stereoscopic visualization (Santos, 2009). Third, full body immersion systems have gained more prevalence. However, these systems are not as user-friendly or compact (Pan, 2006). Furthermore, current HMD sets cost around $400, while full body immersion systems cost upwards of $40,000 (Bolas, 2013). Considering the multiple VR mediums, HMD virtual reality technology holds the highest potential for increasing training effectiveness and lowering costs for corporate training programs (Burdea, 2003).

The following sections briefly describe the existing literature. Then, the experiment and results about HMD immersion and subject interest are presented. Finally, the results of this study are discussed.

Chapter 2

Background

In this section, the advantages of HMD systems over traditional desktop programs are presented. Next, a review of the current literature about HMD's and their current applications are discussed. Finally, the effects of increased fidelity and presence in a HMD are discussed. With fidelity and presence, the focus was on their implications and outcomes for enhancing interest level.

2.1 Advantage of Head Mounted Display Systems

Virtual reality systems outperform traditional desktop programs across multiple domains (Pausch, 2003). First, HMD systems increase the user's presence or "sense of being there" (Slater, 1995). However, immersion promotes the sense of presence. Immersion is the hardware that allows for the psychological state of presence (Datey, 2002). For example, the increased field of view in the HMD masks any visual stimuli from the physical environment surrounding the user, such that the image becomes a reality. In contrast, when viewing a monitor the human brain process peripheral stimuli from the actual environment. For instance, with a monitor condition a participant may notice in his or her periphery how the office lighting reflects off the white walls. However, with the HMD it allows for more focus and immersion in the virtual environment, masking these peripheral stimuli. Participants in the HMD reported feeling "in the environment" as opposed to merely "watching" the environment with a monitor. Nevertheless, current HMD models suffer from lower resolution than the average monitor, which unfortunately hinders the sense of presence (Hua, 2000).

Slater (2003) describes immersion like measuring a color by its wavelengths; immersion is something that science can precisely measure. In contrast, presence is a psychosocial state that requires an operational definition to measure. Following the color analogy, presence is the human perception of color rather than an objective measurement.

Second, fidelity or “the realness of experience” increases in the HMD (Santos, 2009). Fidelity stems from presence (Pausch, 2003). However, fidelity is not a psychological state, but an actual physical experience. While the two overlap a great deal, fidelity is much harder to simulate than presence. Compared to the desktop condition, participants felt the HMD was far more realistic. Overall, the technology is not yet advanced enough for participants to truly feel like the virtual environment was a reality (Hua, 2000).

The third primary benefit of HMD usage is that users receive increased degrees of freedom, more adequate depth cues, and greater spatial understanding and orientation in a virtual headset (Hua, 2000). Increased degrees of freedom allow users a wider field of view and “more real world cues” (Brooks, 1988). Spatial understanding and orientation constitutes a macro approach to understanding the environment. For instance, a participant in an HMD condition should more easily pinpoint his or her location on a map of a virtual environment as opposed to a monitor condition (Pausch, 1997). Furthermore, head movement is more natural than moving a mouse for navigation (Datey, 2002). However, one area of VR that will require a great deal more research is realistic shadowing. The human brain can naturally detect fake shadowing attempts and this is one of the primary signals of a virtual environment (Slater, 1995).With time, technology will only improve the HMD experience. Overall, HMD systems increase immersion, presence, and fidelity as compared with a monitor system.

2.2. HMD Virtual Environments compared to Desktop Virtual Environments

Several studies have concluded that HMD systems are effective for specific areas of training (Abulrub , 2013; Bayarri, 1996; Fast, 2004; Li, 2005; Santos, 2009; Sielhorst, 2004;Stone, 2013). The current study was concerned with the advantages of HMD systems over desktop conditions. In a study conducted by Pausch (1997), they found that participants placed in a virtual room (Desktop and HMD conditions) found a target in the same amount of time. However, when there was no target present in the room then the HMD condition concluded no target was present significantly faster. This supported that HMD head movement are more natural than using a mouse. Then, a study conducted by Raja (2004) found results trending towards significance concerning the effects of immersion on completion of a virtual task. HMD users comprehended and manipulated statistical data more easily than a typical monitor condition. Immersion increases the efficiency of completing virtual tasks.

However, Multiple confounds between a desktop and HMD condition exist, such as field of view, screen resolution, stereoscopic versus monoscopic displays, lag between head movement and the resulting change to the display, and image stability (Robertson, 1997). While it is nearly impossible to isolate each of these variables, together they surmise the differences between a HMD and desktop conditions (Santos, 2009). However, current scholars claim that comparing an HMD condition to a desktop one is irrelevant (Fassbender, 2012). Without strong evidence, reviewers have already concluded that HMD technology is superior. Nonetheless, the current literature offers little evidence to support this claim (Santos, 2009). If companies are going to invest millions in implementing HMD technologies, then VR technology must prove that it is superior to a company's current training programs that use traditional computer monitors.

Chapter 3

The Present Study

A review of the current literature leads to the conclusion that HMD technologies main benefits are increased fidelity and a sense of presence through immersion (Mizell, 2002; Raja, 2004). With this in mind, an important question to ask is, why might these benefits increase training effectiveness? One perspective is that increasing the trainee’s interest leads to superior learning outcomes (Ainley, 2002; Hong, 2012; Kraiger, 1993; Nieswandt, 2008). When personal interest in a subject increases then people view the subject as more meaningful and important. This, in turn, leads to increased effort and better memory retention (Kraiger, 1993; Nieswandt, 2008).

Therefore, if HMD systems increase user interest then learning achievement should also increase (Kraiger, 1993). Two theoretically fundamental forms of interest exist, situational and individual. Individual interest resides in the person and remains relatively stable across situations. However, situational interest emerges as a response to features in the environment (Linnenbrink, 2010). For example, situational interest in a chemistry class may occur because of a phenomenal professor or attention grabbing demonstrations. In contrast, if an incompetent teacher takes that phenomenal professor’s place, then the students’ interest in chemistry would decline. Individual interest exists independent of circumstances. A student with individual interest in chemistry will still enjoy chemistry despite the change of professors. Notably, individual interest most strongly predicts learning achievement outcomes but situational interest can add or detract from achievement (Raja, 2004).

Hidi and Renninger (2006) presented a four-phase model of interest progression. Each of their four phases triggers the next phase. The first and lowest phase is situational interest, which yields a maintained situational interest. For example, the phenomenal chemistry teacher may gradually increase student's subject interest enough that they consistently enjoy the class. Second, maintained situational interest yields individual interest. This is a critical step, which takes place with repeated positive exposure. Third, individual interest produces a maintained individual interest and, theoretically, the highest form of learning achievement (Linnenbrink, 2010).

Like an engaging professor, realistic VR programs should increase participant's subject interest due to the appealing medium. Increased engagement with the material will increase subject interest. Ideally, subject interest would be measured after repeated exposure to a topic through the HMD. Nevertheless, presence and fidelity in HMD systems should increase situational interest, which, in turn, should yield superior achievement outcomes.

The goal of this study was to explore the potential behind implementing HMD technology for increasing subject interest. This study addressed some possible reasons behind why HMD training programs may yield superior training benefits as opposed to standard desktop training program. The first hypothesis was that presence or the sense of "being there" will increase interest. The second hypothesis was that increased interest will lead to increased commitment and greater motivation to learn. If the HMD can outperform a monitor condition for increase subject interest then companies should consider the implementation of HMD systems to enhance the potential for more effective training.

Chapter 4

The Experiment

4.1. Participants

The study involved undergraduate students (n=90) from the Pennsylvania State University subject pool. Once in the lab, participants were randomly assigned to one of four experimental conditions and underwent a space simulation through the Titans of Space program. Random assignment was confirmed via statistical analysis, which showed no significant variations by condition for gender, ethnicity, high school GPA, or college GPA. Participants demographic information is presented in Table 1. Age ranged from 18 to 33, with the mean age of 19. Additionally, none of the participants had prior experience in a HMD system. Although some had limited experience with virtual reality through IMAX theaters and video gaming, these additional experiences were fundamentally different from HMD immersion used in this study.

4.2 Design

The virtual environment was simulated using the Titans of Space program. Titans of Space was designed to teach students about space by taking participants along a predetermined path and stopping at various objects throughout space, objects like the Moon or Jupiter. At each stop, text would appear on a virtual dashboard in front of the user. On average, participants completed the program in 15 minutes. Although no official time measurements were recorded.

The study was a 2x2 design with two HMD conditions (first generation Oculus Rift versus traditional monitor) and two participation conditions (active versus passive). For the active condition with the traditional monitor, participants traveled on a predetermined rout through space and stopped at various objects until the participant clicked the mouse to continue. In the active condition with the Oculus Rift -HMD, like in a video game, participants could actively control their virtual field of view. The active HMD condition allowed participants to manipulate their field of view using head tracking, as opposed to a mouse. For both passive conditions, participants watched a video of the Titans of Space Program. For the passive monitor condition, participants simply watched the video. For the passive HMD condition, participants could manipulate their field of view as if one could when at a movie theater. Participants could not manipulate the program field of view but could choose whether to look at the screen.

Each condition received a pre and post-questionnaire. The pre-test measured participant's subject interest in space and pervious experience with VR mediums. All operational variables were measured using a 1 to 7 Likert scale. To measure subject interest, participants answered questions like, "Am I interested in learning more about space?" The post-questionnaire measured subject interest in space with the same pre-test questions, but asked the questions in a different order. In addition, the post-test measured presence, and virtual reality induced sickness (VRISE). For presence, participants answered questions like, "I thought the program provided a realistic experience" or "The program felt life-like." For VRISE, participants rated their level of nausea, vertigo, dizziness, fatigue, and several more. The VRISE was collected in this study but not used to test hypotheses.

4.3. Procedure

Participants signed up for individual one-hour time slots. Five different undergraduate lab administrators conducted the sessions. After signing an informed consent, participants completed the pre-questionnaire. Next, each participant was assigned randomly to one of the four conditions. The administrator then read the participant the study script. For the active conditions, the administrator explained how to advance through the program and how to control one's field of view. For the passive conditions, the administrator told the participant to watch the video. After completing the program, participants completed the post-questionnaire. Lab administrators we instructed not to prematurely inform participants about the post-questionnaire.

Chapter 5

Results

A repeated subject ANOVA was used to analyze the first variable of interest, space interest. A statistical analysis of the within-subjects effect resulted in statistically insignificant effects across conditions. Interest level did not vary across pre-questionnaire (mean=5.182, SD= 1.053) and post-questionnaire (mean=5.15, SD=1.185); (p=.728) pre and post interest scores were highly correlated (r=.80). No significant variation existed between conditions as shown in table two. In addition, no significant interaction existed between interest levels for the four conditions (Figure 1). HMD use did not increase interest level.

The second variable analyzed was immersion. A between-subject ANOVA resulted in a statistically significant differences in immersion between the active and passive conditions (p=.038). The Active HMD condition (mean=4.293, SD=.197) was the most immersive, followed by the active desktop condition (mean=4.122, SD=.199). The hardware, HMD versus monitor, had no significant effect. Active engagement is more beneficial than the hardware itself. The HMD condition did increase immersion above a monitor condition (Figure 2).

Finally, immersion did not increase space interest, (p=.11) which is a function of the fact that interest in the topic, space, did not change from pre to post-testing.

Chapter 6

Discussion

6.1 Summary of Results

This study investigated the effects of immersion on subject interest. However, subject interest did not significantly change. Pre and post-subject interest levels remained relatively stable over time and across conditions. None of the conditions significantly effected subject interest. Both HMD conditions increased immersion, yet neither influenced subject interest. Either, participants had a rigid interest towards space or immersion ineffectively influenced interest level.

Positively, immersion or the sense of true presence in the environment increased under the HMD conditions. Participants felt as if the environment was much closer to reality. Notably, many participants commented on the poor screen resolution. However, overall participants responded positively to the new technology. They were excited, saw its potential for education, and enjoyed a novel medium of learning. However, the entertainment aspect of VR probably produced the excitement. People enjoy new experiences (Mania, 2001). Unfortunately, it appears most participants enjoyed the experience of the HMD significantly more than the content. Nevertheless, enjoyment of the medium can lead to improved subject interest and learning outcomes (Ainley, 2002; Hong, 2012; Nieswandt, 2008).

6.2 Theoretical Implications

Increasing subject interest level should increase learning outcomes (Ainley, 2002; Hong, 2012; Nieswandt, 2008). However, our inconclusive results yielded uncertain implications. Research on subject interest shows that as participants age their interest level becomes increasingly rigid (Hong, 2012). Therefore, space interest in college freshmen might not change regardless of the effects of immersion. Previous research by Ainley (2002) noted that interest level is more dependent on the subject and less dependent of the medium.

Research is unclear about the exact interaction between immersion and interest level. Immersion increases fidelity, which should increase interest level due to realism (Datey, 2002). However, Hoffman (2001) concluded that the level of fidelity matters most when it reflects the training material. For example, training patients to overcome a phobia requires a high degree of fidelity (Garcia, 2002). Increased interest should reflect a realistic experience. Increased interest in space should occur through a high fidelity simulation. The simulation had a high degree of fidelity but did impact space interest. Consequently, space interest is independent from fidelity.

6.3 Practical Implications

According to the four-phase model of interest progression, one's level of interest about a topic systematically progresses (Hidi, 2006). Theoretically, as immersion increases so would interest level (Kraiger, 1993). However, immersion did not increase interest level. This may be due to the nature of the subject. Space is a common topic that most college individuals have already explored, resulting in a rigid interest level. Perhaps a more novel topic would allow immersion to increase interest level (Hong, 2012). Regardless, most corporate training is mundane (Berge, 2007). Therefore, training through the HMD would not increase interest level. Immersion alone is not a strong enough factor to increase interest level. Conversely, interest level depends more on the subject matter and less on the medium (Ainley, 2002; Nieswandt, 2008). Practically, an interesting medium can increase subject interest. However, this requires repeated expose over time (Hidi, 2006).

Perhaps the interest levels of elementary aged students are more malleable (Salthouse, 2010). If this were the case then younger participants would receive increased benefits from a HMD condition. In addition, younger students have a lower attention span, which increases the need for immersive interactive programs and higher fidelity (Salthouse, 2010). However, corporate professionals want to learn the material using the most efficient and effective means (Berge, 2007). According to our results, HMD technology does not provide a more efficient or effective medium for increasing interest level.

6.4 Future Directions

In regards to increasing interest level through immersion, future studies should compare a novel subject with a mundane subject condition to establish if immersion increases interest. Furthermore, age may moderate immersion effects. Future research should focus on younger participants, perhaps elementary age students, who have a more malleable interest level.

In addition, future research could examine the effects of HMD technology novelty on training outcomes. If participants adequately adjusted to an HMD condition before beginning training, then would training outcomes increase? Furthermore, how long would it take to reduce HMD novelty sufficiently?

While the study did not support the effectiveness of HMD over monitor it is important to continue to investigate this comparisons and others involving hardware. The relatively small sample size, 90 total subjects, had limited statistical power and as such true differences may not have been revealed.

Chapter 7

Conclusions

Overall, fidelity increases immersion and presence. However, fidelity, presence, and immersion do not significantly affect a subject's level of interest in the material. The novelty of the hardware peaked interest in the technology but it did not influence subject interest. Immersion is not always beneficial. It helps most when the data can make more visual sense when presented in three dimensions or when a real scenario is too dangerous or expensive to execute (Mizell, 2002; Pausch, 1997). HMD systems are ineffective for increasing subject interest for common subjects like space. However, for a more novel subject, like a specific period of history, the HMD could significantly impact subject interest.

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ACADEMIC VITA

Nathan Kutz
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EDUCATION

The Pennsylvania State University, University Park, PA — Graduation: Dec 2014

- *Bachelor of Science in Psychology*
- *Minor in Business*
- *Schreyer Honors College Scholar* — **Dean's List Each Semester**

Certification

Pennsylvania Real Estate License

- Caring deeply about doing the right things for clients

LEADERSHIP

Campus Crusade for Christ – State College, PA — Fall 2011-Present

- *Bible Study Leader*
  - Facilitate a small group in weekly discussions while learning effective teaching strategies
- *Discipler*
  - Lead one on one mentorship with four men a week while developing strong motivational techniques, communication, and interpersonal skills

Kings Domain Summer Project, Oregonia, OH — Summer 2012

- *Camp Counselor for Inner-City Youth*
  - Taught underprivileged inner-city youth life skills and Biblical principles
  - Learned conflict resolution strategies, leadership skills, and handled cases of severe poverty

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WORK EXPERIENCE

Resident Assistant – The Pennsylvania State University, University Park, PA — Fall 2013-Present

- Organize and facilitate community building and educational programs for up to 50 residents
- Enforce policies to ensure a safe living and learning environment for all residents
- Learned respect, responsibility, and integrity through leadership

Marketing Intern – Keller Williams, West Chester, PA — Summer 2013, 2014

- Managed clients and gained valuable communication skills
- Streamlined branding strategies and renovated marketing systems
- Learned sales strategies emphasizing a win-win or no deal business plan

Innovation Intern - Calvary Chapel Delaware County — Summer 2013

- Reengineered high school youth ministry and implemented mentorship programs
- Lead a Bible study and mentored high school students

RESEARCH EXPERIENCE

The Pennsylvania State University — University Park, PA

Industrial Organizational Psychology Department — Fall 2013-Present

Undergraduate Research Assistant for Dr. Richard Jacobs

- Create and execute lab studies to further training technology research
- **Honors Thesis:** 3-D immersion technology implementation for executive training purposes

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Study Abroad

India – New Delhi — Summer 2014

- Cultural immersion program studying modernization's effects on education