University of Central Florida
STARS

Electronic Theses and Dissertations, 2004-2019

2015

Investigating Simulation-Based Pattern Recognition Training For Behavior Cue Detection

Crystal Maraj
University of Central Florida

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

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

STARS Citation
Maraj, Crystal, "Investigating Simulation-Based Pattern Recognition Training For Behavior Cue Detection" (2015). *Electronic Theses and Dissertations, 2004-2019*. 1285.
https://stars.library.ucf.edu/etd/1285

INVESTIGATING SIMULATION-BASED PATTERN RECOGNITION TRAINING FOR BEHAVIOR CUE DETECTION

by

CRYSTAL MARAJ
B.A. University of Central Florida, 2008
M.S. University of Central Florida, 2012

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy in Modeling and Simulation
in the College of Engineering and Computer Science
at the University of Central Florida
Orlando, Florida

Spring Term
2015

Major Professor: Stephanie J. Lackey

© 2015 Crystal Somatee Maraj

ABSTRACT

The U.S. military uses pattern recognition training to observe anomalies in human behavior. An examination of the pattern recognition training literature for Warfighters reveals a gap in training to discern patterns of human behavior in live environments. Additionally, the current state of warfare is evolving and requires operations to change. As a result, pattern recognition training must accommodate new practices to improve performance. A technique used to improve memory for identifying patterns in the environment is Kim's game. Kim's game establishes patterns to identify inanimate objects, of which information retains in memory for later recall. The paper discusses the fundamental principles of Kim's game applied to virtual Simulation-Based Training. The virtual version of Kim's game contains customized scenarios for training behavior cue analysis. Virtual agents display kinesic cues that exhibit aggressive (i.e., slap hands and clench fist) and nervous behaviors including wring hands and check six. This research takes a novel approach by animating the kinesics cues in the virtual version of Kim's game for pattern recognition training. Detection accuracy, response time, and false positive detection serve as the performance data for analysis. Additional survey data collected include engagement, flow, and simulator sickness. All collected data was compared to a control condition to examine its effectiveness of behavior cue detection. A series of one-way between subjects design ANOVA's were conducted to examine the differences between Kim's game and control on post-test performance. Although, the results from this experiment showed no significance in post-test performance, the percent change in post-test performance provide further insight into the results of the Kim's game and control strategies. Specifically, participants in the control condition performed better than the Kim's game group on detection accuracy and response time. However,

the Kim's game group outperformed the control group on false positive detection. Further, this experiment explored the differences in Engagement, Flow, and Simulator Sickness after the practice scenario between Kim's game group and the control group. The results found no significant difference in Engagement, partial significance for Flow, and significant difference for Simulator Sickness between the Kim's game and control group after the practice scenario. Next, a series of Spearman's rank correlations were conducted to assess the relationships between Engagement, Flow, Simulator Sickness, and post-test performance, as well as examine the relationship between working memory and training performance; resulting in meaningful correlations to explain the relationships and identifying new concepts to explain unrelated variables. Finally, the role of Engagement, Flow, and Simulator Sickness as a predictor of post-test performance was examined using a series of multiple linear regressions. The results highlighted Simulator Sickness as a significant predictor of post-test performance. Overall, the results from this experiment proposes to expand the body of pattern recognition training literature by identifying strategies that enhance behavior cue detection training. Furthermore, it provides recommendations to training and education communities for improving behavior cue analysis.

Dedicated to…

Mr. George and Mrs. Sylvia Ramroop
Mr. Lionel and Mrs. Rosie Ramlochan
Mr. Gokool and Mrs. Radhica Persad Maraj

"There are special people in our lives who never leave us…even after they are gone." D. Morgan

ACKNOWLEDGMENTS

In writing this dissertation, there are a number of people who have helped me through this process. I am extremely grateful for all their contributions, from simple words of motivation to directing my research path. I would first like to thank my parents, Ainsworth and Lystra Ramlochan, for always lending your moral support and providing me the motivation necessary to complete my Ph.D. Tralisa Maraj, Sarah Ramlochan, Aaron Ramlochan, and Matthew McDonald, thank you for all the love and encouragement you all gave me through this chapter in my life, as well as the chapters that follow. Thank you to Harry Maraj, for your support. I would also like to acknowledge my second family at work. Karla Badillo-Urquiola, for helping me every step of the way, from the start of experimentation to the end of my dissertation. You have stood by me through "thick and thin" and we have forged a sisterly bond that can never be broken. Sushunova Martinez, for always providing kinds words of encouragement when I needed it the most and your willingness to help me with the "little things." Dr. Julie Salcedo, thank you for lending me your ear and being my "go to" person in times of need. Sherry Ogreten, Brandon Sollins, and Jonathan Harris, I am very grateful for your generous contributions to making the experimental process go smoothly. Eric Ortiz, I appreciate you for appreciating me in asking you for your artistic talents in creating the graphics I needed. To Naya Ramirez, thank you for being a second mother to me in times when I needed extra encouragement, love, and support. Your wisdom and kind words have resonated with me from the first day I started at IST until now to obtaining my Ph.D. Our conversations have helped me stayed grounded in my values and endure this lifelong learning process. I would also like to recognize my committee members, Dr. Kincaid and Dr. Shumaker for guiding and mentoring throughout the dissertation process. I have learned a great deal from your

mentorship over the past year. Joe Keebler, thank you for recognizing my potential and encouraging me over the years to never give up. I value and admire your passion for research, and am very grateful that I have been able to share with you moments that promote innovative discussion. Last, but definitely not least, to my mentor Stephanie J. Lackey. I am very grateful for your endless patience and guidance. As a successful female Lab Director, you are an inspiration to me, as well as other young, upcoming professionals in this field. Thank you for your 1 minute, 3 minute, or 5 minute pep talks during my "Why am I doing this?" moments. These have motivated me to keep on track and reach my end goal. Our casual conversations over the years have transformed into a lasting and respectable relationship.

A special thank you to the U.S. Army Research Laboratory for supporting this research endeavor. I hope my findings are useful for the research and development of future training technologies that support military operations.

TABLE OF CONTENTS

LIST OF FIGURES xii

LIST OF TABLES xiii

LIST OF ACRONYMS xiv

CHAPTER 1: INTRODUCTION 1

CHAPTER 2: LITERATURE REVIEW 5

Change Blindness 5

Change Detection 7

Perceptual Training 10

Information Processing 11

Pattern Recognition 13

Memory 16

Combat Profiling 18

Current Training Methods for Pattern Recognition in the Military 19

Kim's Game 21

Simulation-Based Training 22

Virtual Environments 23

Engagement 25

Flow 26

Working Memory 26

Proposed Study 27

CHAPTER 3: METHODOLOGY 28

Experimental Design 28
Independent Variable 28
Experimental Condition 28
Control Condition 28
Dependent Variables 29
Performance Data 29
Survey Data 30
Participants 31
Experimental Testbed 32
Experimental Terrain 33
Virtual Models 33
Virtual Camera 34
Behavioral Cues 34
Kim's Game Task Layout 36
Event Trigger Layout 37
Calculations for Practice Videos 40
Calculations for Pre/Post-Test 41
Targets and Non-Targets 41
Non-Target Cues 42
Procedure 42
CHAPTER 4: RESULTS 45

Preliminary Data Analyses 45
Performance Analyses 46
Pre-Test Performance 46
Post-Test Performance 46
Percent Change 47
Kim's Game: Pre-Test vs. Post-Test Performance 47
Control: Pre-Test vs. Post-Test Performance 48
Engagement Performance 49
Flow Performance 49
Simulator Sickness Post Practice Performance 50
Survey Analyses: Correlations 51
Engagement and Post-Test Performance 51
Flow and Post-Test Performance 52
Simulator Sickness and Post-Test Performance 52
WM and Training Performance 53
Survey Analyses: Multiple Linear Regressions 53
Engagement as a Predictor of Post-Test Performance 53
Flow as a Predictor of Post-Test Performance 54
Simulator Sickness as a Predictor of Post-Test Performance 55
CHAPTER 5: DISCUSSION 56
Performance 56
Engagement 58

Flow 60

Simulator Sickness 62

Working Memory 64

CHAPTER 6: CONCLUSION 65

APPENDIX A: PRE EXPERIMENT QUESTIONNAIRE 68

APPENDIX B: DEMOGRAPHICS QUESTIONNARE 70

APPENDIX C: ENGAGEMENT MEASURE 73

APPENDIX D: FLOW STATE SHORT SCALE 76

APPENDIX E: SIMULATOR SICKNESS QUESTIONNAIRE 78

APPENDIX F: IRB APPROVAL LETTER 80

LIST OF REFERENCES 83

LIST OF FIGURES

Figure 1: Common Elements of the Pattern Recognition Processes..... 2

Figure 2: SBT Justification Gap (Haque & Srinivasan, 2006; Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2011; Nicholson, Schatz, & Bowers, 2008) 4

Figure 3: Aspects of change blindness mapped to the general pattern recognition processing model 7

Figure 4: Aspects of change detection mapped to the general pattern recognition processing model 9

Figure 5: Aspects of perceptual training mapped to the general pattern recognition processing model..... 11

Figure 6: Aspects of human information processing model mapped to the general pattern recognition processing model 13

Figure 7: Aspects of pattern recognition mapped to the general patterm recognition processing model..... 16

Figure 8: Aspects of pattern recognition mapped to the general pattern recognition processing model..... 18

Figure 9: VBS2 Testbed..... 33

Figure 10: Event Trigger Layout 39

LIST OF TABLES

Table 1: Target and Non-Target behavioral cues. Adapted from (Salcedo, 2014) 35

Table 2: Kim's Game Task Layout 36

Table 3: Calculations for Kim's game practice video 40

Table 4: Calculations for video clip length 41

Table 5: Calculations for Pre/Post-Test Targets, Non-Targets, and Non-Target cues 42

Table 6: Experimental Procedure 44

Table 7: Reliability Analysis for Survey Data 45

Table 8: ANOVAs for Percent Change 47

Table 9: Paired Samples T-test for Kim's Game 48

Table 10: Paired Samples T-test for control group 48

Table 11: ANOVA's for Flow between Kim's game and control groups 50

Table 12: ANOVA's for SSQ between Kim's game and control groups 50

Table 13: Correlations between Engagement and Post-Test performance (*n*=75) 51

Table 14: Correlations between Simulator Sickness and Post-Test Performance (*n*=75) 53

LIST OF ACRONYMS

ES	Every Soldier is a Sensor
FOV	Field Of View
HVHT	High Value Human Target
ISI	Interstimulus Interval
ISR	Intelligence, Surveillance, Reconnaissance
KSA	Knowledge, Skills and Abilities
LTM	Long-Term Memory
ME	Massed Exposure
MS	Milliseconds
NASA-TLX	NASA-Task Load Index
OSPAN	Operation Span Test
SBT	Simulation-Based Training
SbT	Scenario-based Training
STM	Short-Term Memory
SSQ	Simulator Sickness Questionnaire
VBS2	Virtual Battlespace 2
VE	Virtual Environment
WM	Working Memory

CHAPTER 1: INTRODUCTION

The world of the 21st century is full of information; at almost all moments of waking life, technology constantly bombards individuals with incoming data. Technology presents information in many forms such as visual, audio, and tactile and distributes information through outlets like television broadcasts, newspapers, computers, cell phones and individuals. This volume of information can become overwhelming and the task of sifting through and deciphering important cues among large amounts of materials can be daunting. To further compound matters, individuals have a tendency to overestimate their ability to identify changes (Simons & Levin, 1997) or are unable to recognize patterns.

The pattern recognition process describes how to identify patterns that exist in the environment. Specifically, pattern recognition involves observing data to establish commonalties or differences in a visual scene. Research dating back to the 1960s examines the pattern recognition process of machine learning to include attributes such as "feature definition, extraction, and classification" (Kanal, 1974). These basic components laid the foundational pieces for the pattern recognition process for years to follow. Liu, Sun and Wang (2006) offer new approaches to pattern recognition training by adopting a human-centered approach. The human-centered approach utilizes the information processing system (i.e., transduction→ feature extraction → classification→ post-processing) to channel incoming information and allows for a decision as to whether a pattern exists or not (Liu, Sun, & Wang, 2006). Other approaches to pattern recognition utilize simulations to identify behavioral and physiological emotions that in turn train the learner. The learner identifies the affective signal, engages in feature extraction to determine if a pattern exists, then makes a final evaluation (Pentland & Choudhury, 2000; Picard, 1995).

From the mid 1990's to 2014, the focus has shifted from statistical and neural computations to identify patterns. The practical significance of these simulation models present challenges to users (e.g., difficult implementation, high-cost, or impractical) (Wolski, 2013) in complex and dynamic real-world events. Improving pattern recognition training is largely dependent on the user to improve their ability to make an accurate decision when observing the environment. The pattern recognition process engages the viewer to evaluate the visual stimulus through observation of the environment, analyzing the target, and then comparing a previous experience to make a decision as to whether there is a match.

Past research efforts have identified how experts make decisions in arduous conditions utilizing naturalistic decision making to build a model from their choices (instead of creating ideal strategies for decision-making) (Klein G. , 2008; Klein & Calderwood, 1991). However, there is very limited research on the pattern recognition process for novices. To explain the pattern recognition process for novices, evolving research for discerning patterns in the environment resulted in the development of a conceptual model (Figure 1).

Figure 1 summarizes typical features of pattern recognition processes from 1968 to 1996 to generate a conceptual model to detect whether or not there is a change in the environment.

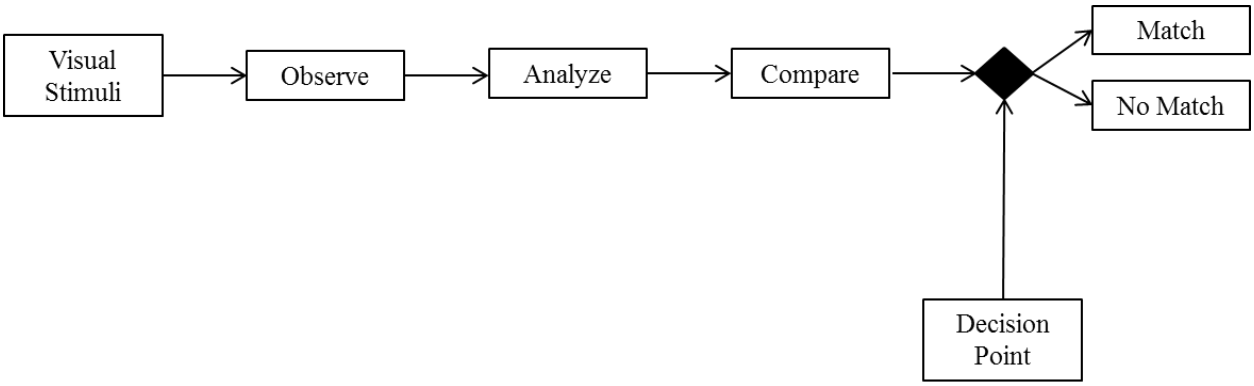

Figure 1: Common Elements of the Pattern Recognition Processes

The primary goal for pattern recognition training is to improve decision accuracy. One application area for pattern recognition training is the Military domain. Today, Military warfare continues to evolve as irregular and unpredictable fetes. As a result, training methods must accommodate for new practices and improved tactics in variable conditions. Additionally, declining budgets in military modernization demonstrates the need for effective training to increase readiness for combat (Department of Defense, 2013). A review of the U.S. Army formal curriculum conducted by Fischer and Geiwetz (1996) shows Warfighters receive limited training for detecting tactical patterns (e.g., enemy unit and terrain patterns) in the environment. Fischer and Geiwetz (1996) further state that Warfighters gain the majority of pattern recognition training through experience in the operational environment. Existing research is limited in regards to pattern recognition for military training: specifically, the effectiveness of observational training to detect changes in the environment (Caldwell & Stinchfield, 2011).

Simulation-Based Training (SBT) offers the opportunity to specialize and adapt training. Typical Warfighter training includes classroom-based instruction followed by live training in a specified geographic location. Classroom instruction provides theoretical foundation (e.g., rules, doctrine, current relevant information, etc.) for improving tactical skills. However, when classroom instruction applies to live training, there is a real problem for Warfighters to transfer and apply high-order skills (e.g., coordination, tactics, decision-making, etc.) (Spain, Priest, & Murphy, 2012). While live training provides an opportunity for the use of actual equipment, tools, and devices in a realistic combat situation, it can also create real-life threatening situations that may cause injury.

SBT as an instructional tool fills the existing gap between traditional classroom and live training (Figure 2) and also enhances Warfighters' performance (Haque & Srinivasan, 2006;

Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2011; Nicholson, Schatz, & Bowers, 2008). SBT creates customizable training scenarios using Virtual Environments (VEs) (Grant & Galanis, 2009; Steadman, et al., 2006; de Freitas, 2006) to assess the effectiveness of training strategies on performance.

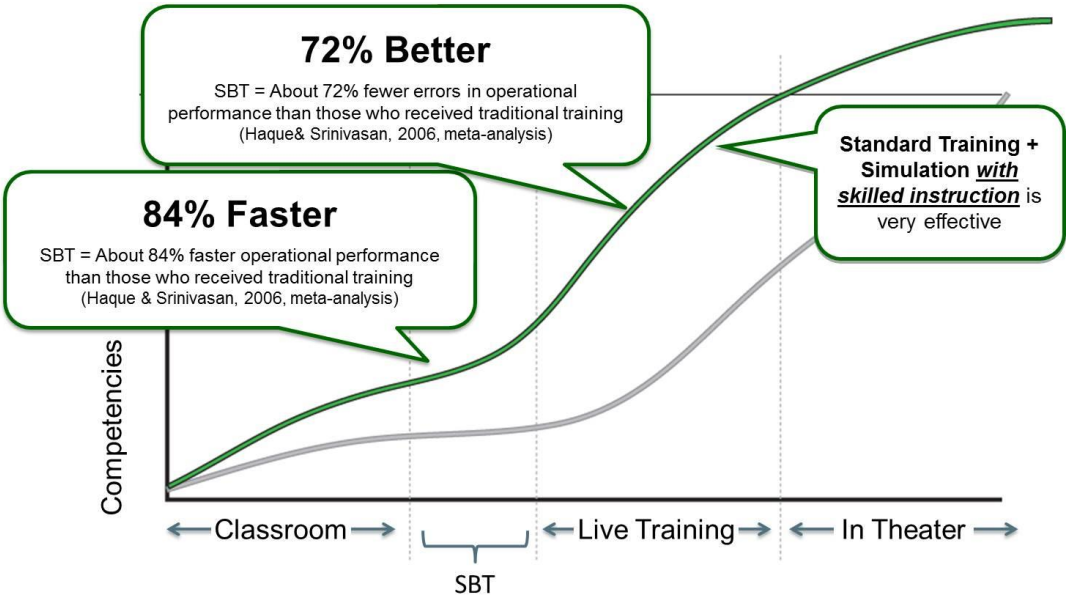

Figure 2: SBT Justification Gap (Haque & Srinivasan, 2006; Vogel-Walcutt, Gebrim, Bowers, Carper, & Nicholson, 2011; Nicholson, Schatz, & Bowers, 2008)

The purpose of this research is to investigate the use of SBT for enhancing pattern recognition skills. The pattern recognition task for this experiment involves observational and perceptual skills required for identifying human behavior cues. The objective of this research endeavor is to assess the effectiveness of simulation-based pattern recognition training on behavior cue detection by examining performance and perception data.

CHAPTER 2: LITERATURE REVIEW

The world we live in is constantly changing around us. The human brain is actively observing, analyzing, and comparing patterns that affect the decision-making process. To understand what pieces contribute to the decision-making process for pattern recognition, it is important to discuss how patterns are discerned in the environment. The fundamental building blocks of the pattern recognition process include: change blindness, change detection, perceptual training, information processing system, memory, and pattern recognition. A thorough discussion on how each area relates to the pattern recognition process model will be provided, as well as applications to the military domain will be offered. Finally, this experiment proposes a pattern recognition task for evaluating user's perception.

Change Blindness

Change blindness results when there is a failure to observe changes in a visual scene. Studies into the change blindness phenomena focus on distractors such as eye blinks, a blank screen, or another simultaneous event for failing to detect a change (large or small) within a visual scene (Simons, Franconeri, & Reimer, 2000; Durlach, 2005). Previous research conducted by Grimes (1996) and Simons and Levin (1997) show that over 50% of observers miss changes when they are actively searching a scenario.

Change blindness occurs at the peripherals of a visual scene as well as the center of scene. Pessoa and Ungerleider (2004) indicate when a stimulus changes, attention is drawn to that area to facilitate visual processing. To that effect, change detection is noticeable when the change signal is clear; the original version changes to a new version instantly, but the change is visible.

Rensink et al. (1997) suggest focused attention is necessary to notice changes in a visual scene. Results show change blindness occurs even when the participant expected a change to take place and their attention shifts throughout the entire scene. As a result, the need for focused attention at the time of the change is important rather than relying on past memory of the scene to be successful at the discrimination task.

Past research highlights discrete and continuous change blindness tasks to evaluate performance. Discrete change blindness occurs when an individual is unable to discern changes in a visual scene following a disruption in the scene. Continuous change blindness is an inability to notice a change in a continuous visual scene. While most studies focus on discrete change blindness, Simons, Franconeri, and Reimer (2000) compared discrete change blindness to continuous change blindness where participants indicated whether they observed a color change in the visual scene. The results demonstrated that performance on the change detection task in the discrete condition was significantly higher than the continuous condition.

Barber, Leontyev, Davis, Sun, and Chen (2007) simulated a multi-tasking environment for remote operation of unmanned systems. The line of research focused on a continuous change blindness task as a manipulator for workload during specific periods that contribute to adaptive automation systems. However, the effectiveness of the task as a manipulator was not clear from the results. Despite these limitations, continuous and discrete change blindness tasks continue to have practical research application for training.

Figure 3 maps aspects of change blindness that fit the general pattern recognition model. The inability to observe and identify changes (change blindness) as well as the presence or absence of focused attention affects observation of the visual scene and influences the decision to find a match or no match.

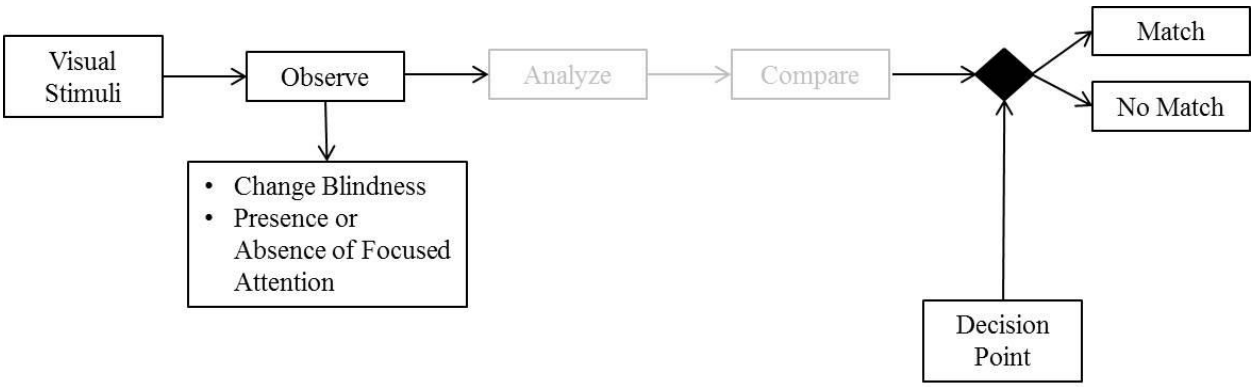

Figure 3: Aspects of change blindness mapped to the general pattern recognition processing model

Change Detection

A concept related to change blindness is change detection. A review of the current literature reveals minimal use of VEs to train change detection. Past examples of change detection have focused on: (1) repeated changes that allow for time as a measure of performance, (2) integrating results using different kind of manipulations (e.g., temporal gap, eye movement, and detecting gap-contingent changes) (Rensink, 2002), and (3) stimuli that are more realistic [representative of] real-world scene (Rensink, 2002; Pessoa & Ungerleider, 2004).

The bulk of research on change detection experimentation focuses on when a change occurs. Techniques such as the *Shift-Continent Technique* and *Gap-Contingent Technique* manipulate what the screen displays when the change detection task occur (Blackmore, Brelstaff, Nelson, & Troscianko, 1995). One variation described by Rensink (2002) of the *Gap-Contingent Technique* postulates a *one-shot approach* where the changes made occur once during each trial. The experiment focused on a single change separated by an opaque display. The approach attempted to limit eye movement by focusing on a single entity, which in turn reduced cognitive overload.

The human eyes have the ability to observe a dynamic or stationary scene very quickly. Change detection tasks that have dynamic displays (e.g., movies) achieve a greater visual realism, but less control of the physical environment (Rensink, 2002; Simons & Levin, 1997; Gysen, De Graef, & Verfaillie, 2000). Gysen, De Graef, and Verfaillie (2000) observed that individuals found it difficult to identify changes to stationary stimuli, whereas changes to dynamic objects were easier to detect.

Past research highlights various ways to analyze changes to a visual scene. One way to assess changes within a visual scene is to add or delete an item. Previous experiments using this type of change detection technique have concluded unique items are easier to detect in instances where an item is removed rather than added (Rensink, O'Regan, & Clark, 1997; Hollingworth & Henderson, 2000; Aginsky & Tarr, 2000; Mondy & Coltheart, 2000). These results compliment the work of Agostinelli, Sherman, Fazio, and Hearst (1986) and Mondy and Coltheart (2000) who support the use of feature matching process to detect items or objects based on corners, edges, or interest points.

Another way to analyze changes within a visual scene is to focus on the spatial arrangement of the displayed item. Specific attention is given to the spatial properties of an object based on layout or placed in relation to other items. According to Simons (1996), layout changes are easier to detect, whereas in other instance it may be more difficult. Deciphering spatial arrangements maybe due in part, to how the brain encodes the information as either a single entity or several distinct parts. Spatial arrangement impacts change magnitude. Tollner (2006) explains change magnitude as small, medium, or large changes based on icon movement of 50, 100, and 150 pixels respectively. Therefore, changes are determined by moving the location of an item from one place to the next.

When selecting a threshold to differentiate change from no-change in a visual scene, Lu, Mausel, Brondizio and Mora (2010) suggest one of two methods: (1) interactive procedure or trial-or-error; (2) statistical measure which selects a suitable standard deviation from a class mean. While these methods have their advantages, other researchers have selected an Interstimulus Interval (ISI) based on the type of change detection task. Empirically driven research examples include Goldstone's (1994) experiment on applying ISI to a perceptual task for detecting changes presented in a VE. The perceptual discrimination task involves presenting an image for 1000 milliseconds (ms), a blank screen for 33ms, and then displaying a second screen for 1000ms. Earlier work by Pashler (1988) on "familiarity and visual change detection" determined that optimal performance occurred at an ISI of 34 ms. Within this body of research, Pashler (1988) referenced Phillips' (1974) work on ISI; suggesting less than 100ms achieves excellent performance when detecting unfamiliar visual stimuli.

Figure 4 outlines components of change detection to explain how pattern recognition works. Ultimately, this affects the decision point under time restrictions to determine if a match or no match is found.

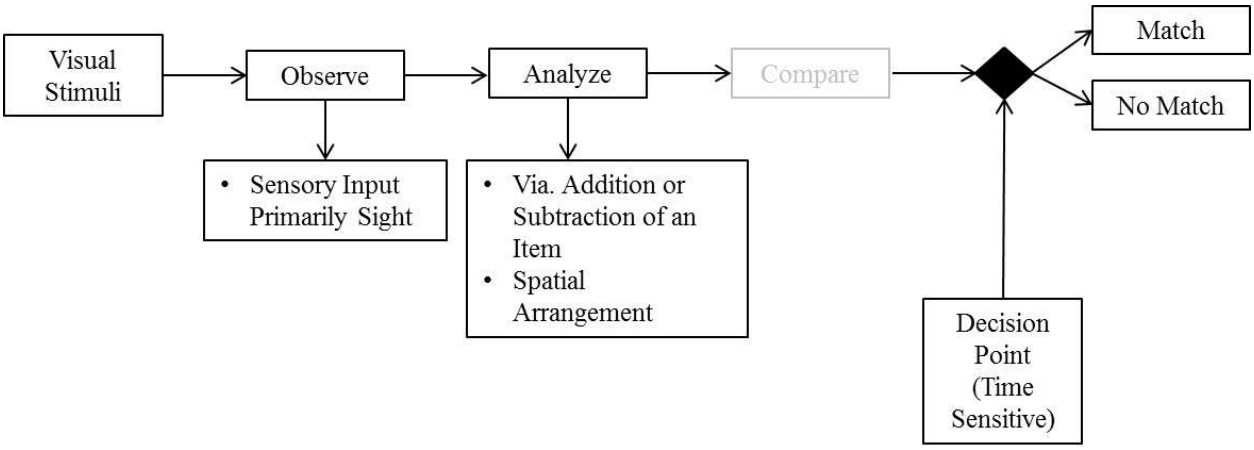

Figure 4: Aspects of change detection mapped to the general pattern recognition processing model

Perceptual Training

Perceptual training involves processing sensory information in order to understand the environment. The sensory system introduces information through sight, sound, touch, taste, and smell to make a decision. Unlike past pattern recognition models where feature extraction is important component, perceptual training of visual search focuses less on "features, status or conjunctions of features" (Sireteanu & Rettenbach, 1995; Budde & Fahle, 1998) for comparison. Examples of perceptual training may include a simple, basic discrimination task (e.g., identifying a potential target) to more complex and intricate visual tasks such as baggage screening or radiology diagnosis.

Perceptual training has shown to improve an individual's ability to respond to the environment (Goldstone, 1998). It offers new ways to decipher relevant characteristics or features within the environment. One way to strengthen perceptual skills for detecting changes in the environment is repeated exposure to the stimuli. Goss (1953) as well as Gibson and Gibson (1955) observed that pre-exposure to stimuli improves the ability to later complete the discrimination task. According to Vanderplas, Sanderson, and Vanderplas (1964), tests that require discriminative or recognition of a stimulus, appear to have larger and positive training transfer for tasks that involve observation.

Figure 5 applies facets of perceptual training to the general pattern recognition model. For pattern recognition training, observing the environment through the sensory system assists with detecting the visual stimulus. Repeated exposure to the potential stimuli is one strategy used to determine if a possible match exists.

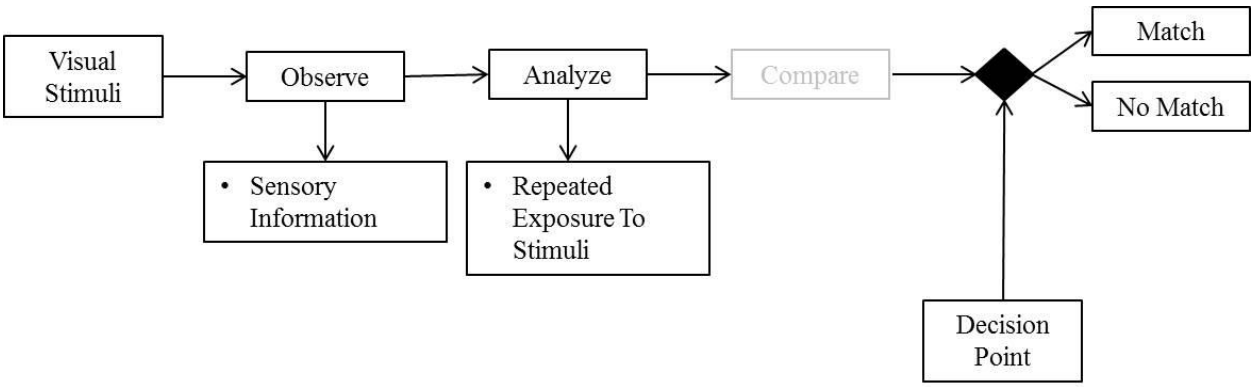

Figure 5: Aspects of perceptual training mapped to the general pattern recognition processing model

Information Processing

The human brain interprets information from the environment, which creates a decision followed by a deliberate response or action. The ability to process incoming information is important for enhancing cognitive, perceptual, and motor skills (Wickens, 2002). Components of the human information processing system have been included in the general pattern recognition process model to create an advanced paradigm describing how the brain recognizes pattern in the environment. A visual stimulus is observed through the sensory system, attention, perception, and transduction. The sensory system interprets energy from the world so that the brain understands and creates a new memory (Huitt, 2003). Transduction is a process of converting energy into neural messages that the brain is able to perceive (Myers & Straub, 2007).

The cognitive subsystem analyzes the newly formed memory through mental organization and interpretation. Cognitive processing compares the incoming information to previously stored knowledge in efforts to improve comprehension and generate responses. One main aspect of cognition is attention. In cognition, attention is the process of actively selecting a stimulus when presented with multiple, competing stimuli in the environment. Paying attention to a specific stimulus allows for further processing of information while discarding other pieces of information.

The information that is further processed passes through several stages, including the phonological and episodic memory systems, until it is comprehended by the central executive system. According to LaBerge and Samuels (1974), the stimulus goes through several stages of processing within these systems to promote learning. Learning is evaluated using two measures: accuracy and automaticity. Accuracy requires attention for processing information, unlike automaticity. Incoming information is streamlined at the automatic level to locate any commonalities or comparisons with previously stored information at the executive level.

Despite the lack of consensus to what exactly constitutes the executive processes of the central executive system, past research suggest that this system "functions as an attention-controlling mechanism" within memory (Pastorino & Doyle-Portillo, 2012). The central executive works with the other subsystems (e.g., phonological, episodic, visuospatial sketch pad, etc.) to coordinate, integrate, and regulate incoming information. The central executive system makes the final decision based on the information from the phonological and visuospatial loop systems. The central executive system is very important for tasks that require attention, such as pattern recognition or using visual and auditory information to coordinate a task (e.g., playing a video game) (Baddeley A. , 1992). Figure 6 is a representation of the information processing system and its different subsystems.

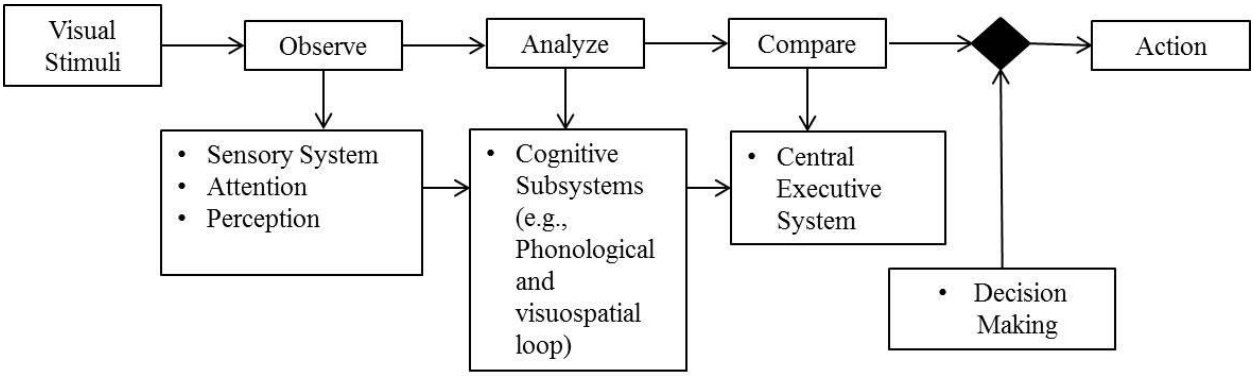

Figure 6: Aspects of human information processing model mapped to the general pattern recognition processing model

Pattern Recognition

According to Fischer and Geiwetz (1996), "pattern recognition is fundamental to human information processing and functioning because it constitutes the first interaction between the environment and mind." When an individual views the environment, visual patterns occur centrally and within the peripheral view. Central vision allows an individual to directly look and describe an item in detail (e.g., recognition of behaviors, objects, persons, etc.). Peripheral vision extends the visual scope outside the central visual area, and is useful for getting a complete picture (Larson & Loschky, 2009). When observing the environment, people most often focus their attention on item(s) that are noticeable in one way or another. If something in the scene is salient, the observer is attracted to or focuses on that specific object.

The human brain processes visual information in one of two ways: top-down or bottom-up approach (Connor, Egeth, & Yantis, 2004). A top-down approach considers the whole picture, which is then broken down into smaller parts. In other words, the brain organizes and processes information into smaller segments. The top-down approach to pattern recognition looks at data stored from past information and events. Data retrieval depends on generalizations or well-defined laws to make conclusions about a particular example, instance, or case. When examining a

situation in a dynamic environment, often times an individual's previous experiences affect their heuristics. For example, veteran Warfighters may quickly make decisions based on experience or intuition instead of actual information from the world. Top-down processing can interfere with identifying potential targets; however, with appropriate training improve detection and accuracy skills.

A bottom-up approach takes small pieces of information that are chunked together to create higher level processing until the top level processing is achieved. Similar to the top-down approach, attention is given to salient features or stimulus of relevant importance. However, in the bottom-up approach, the individual starts with no previous knowledge on the subject matter. The bottom-up approach uses inductive reasoning to create generalizations drawn from particular examples by capturing common properties between them.

Top-down and bottom-up approaches guide the viewer's attention when observing the environment. According to Thompson, Bichot, and Schnall (2001), there is evidence to suggest that accurately performing visual search trials involves a combination of bottom-up and top-down influences. Saliency results from top-down and bottom-up influences, where features become apparent by combining low-level features of bottom-up models (e.g., orientation, color, and intensity) with top-down cognitive visual features (e.g., faces, humans, and cars) (Yarbus, 1967; Thompson , Bichot, & Sato, 2005).

One method for analyzing patterns in the environment is feature analysis. Feature analysis generates a features list (e.g., lines, edges, angles, etc.) which compares to a stored feature list in memory to recognize patterns in the environment (Morgan, 2003). Selfridge's (1959) paper, "Pandemonium: A Paradigm for Learning," for neural networks and machine learning developed the idea of "demons" to describe how patterns are recognized in the environment through visual

processing. Demons are "small, specific processes, waiting for a chance to act" (Selfridge, 1959). Demons interact with other demons to motivate and facilitate learning (e.g., identifying features of an object). Based on the theory about neural networks, visual processing influences the recognition of human behavior patterns in the environment (Dolan, 2002).

The overall goal of pattern recognition is to identify a match between the visual sensory input and previously stored data. The template matching theory suggests that objects are compared to pre-defined templates stored in memory for pattern recognition (Lund, 2009). However, the number of elements in the environment typically exceeds the brain's data storage capability and only retains some of the properties of a finite number of objects. As a result, many different patterns of information are recognized as examples of the same element, object or concept. This is challenging when features of an object is inaccurately identified in the environment.

General theories of object recognition consider what the human brain does to compensate for changes that occur in the external environment. Seemingly, different schools of thought examine the perceptual recognition of objects using sensory input, determines which processes recognize the object and how it is encoded in the brain (Tarr & Vuong, 2002; Bulthoff & Edelman, 1992). Two different approaches explain how objects are recognized based on its transformation.

According to Tarr and Vuong (2002), one group of theorists asserts that there are a specific set of cues activated to identify an object in most viewing instances. The coined term *viewpoint-invariant* suggests that information recalled from the brain determines the image of an object despite any changes that occur (Biederman, 1987; Marr & Nishihara, 1978). Another group of theorists argue that no such distinction exists and that object features are stored in the brain. The image is stored as a snapshot representation in visual memory (Bulthoff & Edelman, 1992). There is match between "the input image and candidate representations" for pattern recognition (Perrett,

Oram, & Ashbridge, 1998). The theories presented identify how humans are able to detect changes that are dynamic in the environment. Overall, it is important to sharpen one's detection skills for identifying visual cues in an operational environment. Figure 7 links elements of pattern recognition to expand the general pattern recognition model by describing how visual stimuli observe, analyze, and compare to make accurate decisions towards a possible match or no match.

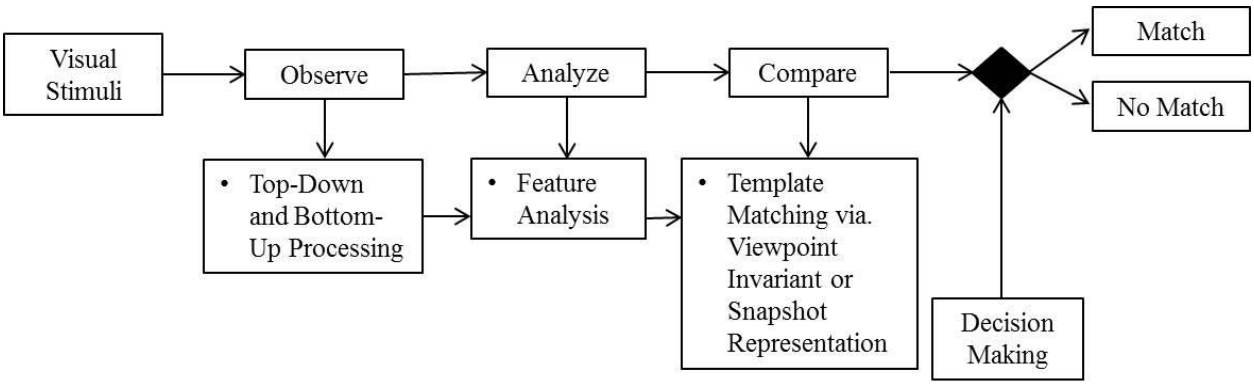

Figure 7: Aspects of pattern recognition mapped to the general patterm recognition processing model

Memory

The sensory system registers visual stimuli presented in the environment. Each sensory receptor connects to neural pathways that send information to the brain. The sensory input system processes a limited number of visual attributes consisting of motion, orientation, and color (Wolfe & Horowitz, 2004) with unlimited capacity; however, this input of information is held for approximately 2 seconds before it is lost (Palmer, Fencsik, Flusberg, Horowitz, & Wolfe, 2011).

Short-Term Memory (STM) occurs when an individual analyzes information through a conscious experience at a given moment. Large amounts of information are not contained but rather held for a short period. The amount of information retained depends on an individual's memory span. Items or chunks are pieces of information recalled immediately without errors. In

most instances, individuals can recall 7 ± 2 chunks of information (Peterson, 1966; Miclea & Opre, 2004; Miller, 1956). STM holds information for 18 to 20 seconds (Peterson, 1966), unless the information is rehearsed or retrieved from memory. It is an active process related to selective attention, that allows an individual to orient their attention to a particular stimulus while ignoring other parts of the environment (Peterson, 1966; Downing, 2000).

Baddeley's (1974) model of Working Memory (WM) is a predictor of "cognitive skills such as reading, comprehension, and reasoning." Thus, WM links to higher-level cognitive processing skills. Research into visual WM suggests that information is stored based on the object's perception rather than individual features similar to verbal WM where *chunks* of information is stored. Attention may be given to several items at any one time (Luck & Vogel, 1997; Rensink, 2002; Miller, 1956). Rensink's (2002) work on change detection proposes that a person could hold 4-5 items at a given time in memory, while the number of items lost would be contingent upon the implemented task. If each scenario includes independent entities, then each entity is evaluated at a specified time. Therefore, a single event is equal to one entity that occurs at a given point.

As previously mentioned, WM has a limit as to the amount of information held and the number of functions performed (Van Gerven , 2003). Processing information held in WM assists with learning new and difficult tasks. One major factor when considering the use of WM is the number of items attended too. If too many items are presented, then the complexity of the task increases and the overabundance of information promotes cognitive overload.

Figure 8 demonstrates the points of impact memory have on the general pattern recognition process. Specifically, the sensory registers observe the visual stimulus in the environment, held in STM and WM. If the information presented lacks recall from LTM, it may eventually become lost

or encodes to form new memories. This affects response time to make an accurate decision because it is difficult to find an immediate match to the observed stimulus.

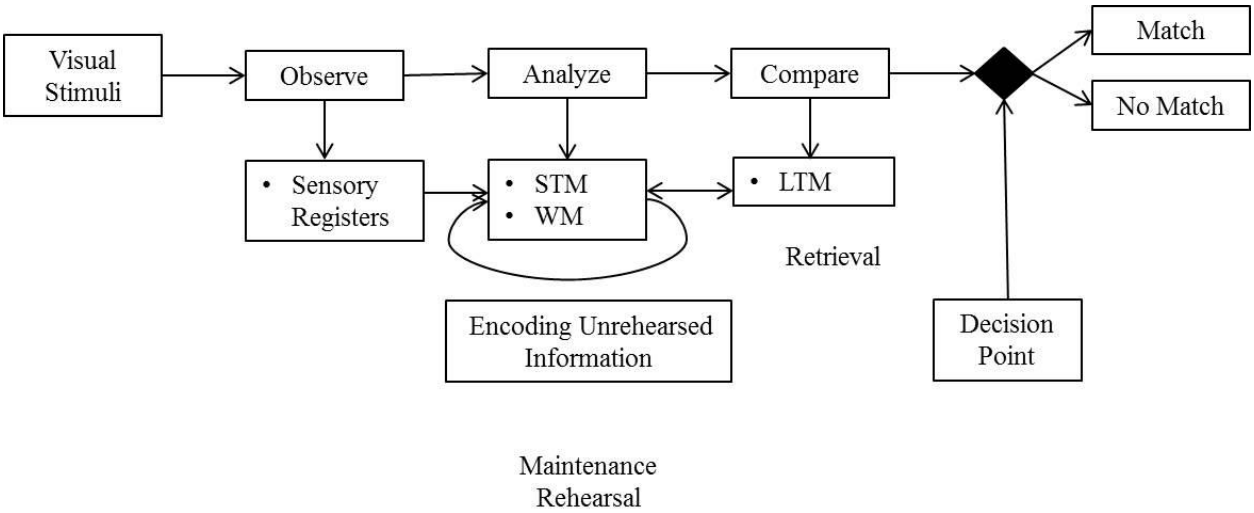

Figure 8: Aspects of pattern recognition mapped to the general pattern recognition processing model

Combat Profiling

Combat profiling is pivotal to application areas for pattern recognition training. One application area is the Military training domain. Combat profiling evaluates dynamic human behavior within a complex, combat environment (Schatz, Reitz, Nicholson, & Fautua, 2010). It affords proactive identification of threats or imminent actions based on human behavior analysis. Warfighters rely upon skills such as pattern recognition, observation, identification, and critical thinking to observe and judge behavior. It involves identifying and synthesizing behavioral cues into meaningful patterns for interpretation (Colombo, Dolletski-Lazar, Coxe, & Tarr, 2012).

In combative environments, an established baseline of human behavior occurs through visual processing. A combination of bottom-up and top-down visual processing increases accuracy for identifying potentially threatening situations; however, may limit familiarization of new

environmental features, terrain, or people. Applying visual processing can heighten visual attention for identifying patterns of irregular behavior in both familiar and unknown territories.

Warfighters identify anomalies through observation of human and socio-cultural behavior domains based on the six domains of Combat Profiling (Ross, Bencaz, & Militello, 2010; Gideons, Padilla, & Lethin, 2008). This experiment focuses on representing kinesic cues in a VE. Kinesics refers to the study of nonverbal cues intended to convey the true meaning of someone's actions (Birdwhistell, 1970). Kinesics centers on observing body language, facial expressions, gesturing, and posturing. Kinesic cues elicit an emotional state based on physicality such as covering the mouth when an individual is lying or fist clenching when an individual is angry (Ross, Bencaz, & Militello, 2010; Colombo, Dolletski-Lazar, Coxe, & Tarr, 2012). Training to make an accurate decision as to whether a match exists in the pattern recognition model is important for identifying potential targets. Warfighters as well as other high-risk occupations such as Law Enforcement Agencies and First Responders may benefit from pattern recognition training to improve their decision making process.

Current Training Methods for Pattern Recognition in the Military

A review of the literature on pattern recognition training for Warfighters has been sparse. Where the term pattern recognition appears within the military training literature, it is associated with fingerprint matching, handwriting recognition, facial recognition, and speech detection (Jain, Duin, & Mao, 2000; Fadde, 2009). Currently pattern recognition training is inadequate for developing threat detection skills. Fischer and Geiwetz (1996) examined the Army's formal curriculum, which shows that Soldiers do not receive formal training for detecting patterns within the environment. Soldiers gain pattern recognition skills over the years because of field experience. To understand where there are deficiencies in training, Fischer and Geiwetz (1996) conducted a

pilot study of pattern recognition training. The results demonstrated that with formal pattern recognition training, Soldiers performed better than those who received the traditional classroom training and at the same level as the Army captains.

Currently, the United States Marine Corps' Scout Sniper School curriculum utilizes observational games (e.g., Kim's game) for improving the detection of high-value targets (Robert & Baden-Powell, 1921; Sniper Sustainment Training, n.d.). Additionally, target detection is a main component of sustainment training for snipers. Snipers practice target detection exercises to identify, define, and plot objects that appear to be hidden or described without using optics. Snipers learn to increase memory processes through repeated trials or exposure to Kim's game. The game requires the person to memorize objects in a systematic detailed manner for later recall of the observed objects. Outcome of acquired skills through use of Kim's game include:

- Advanced observation skills
- Increased awareness and attention to detail
- Ability to observe and dissect environment critically
- Rapid memorization
- In-depth descriptive skills

The U.S. Army has also developed training programs such as the Every Soldier is a Sensor (ES) program where Soldiers routinely observe and report patterns and changes in the operational environment through primary interaction with the local population. Soldiers train to answers fundamental questions that shape their environment such as who are the leaders, opening and closing times of the market places, and eating and sleeping patterns of the locals. Social norms include what the streets look like during different times (i.e., crowded or empty) and traffic patterns

(Joint Staff of the Department of Defense, 2013). This training program emphasizes environmental pattern recognition, pivotal to identifying changes in the environment that prevent future attacks.

It is evident from the literature that instituting formal pattern recognition training into the curriculum is effective for training. Further, the need for pattern recognition training is underdeveloped and underutilized; but necessary for continued survival in warfare. A Soldier's ability to engage in vigilant observation and detection of real-world events affects his or her performance especially in hostile territories.

Kim's Game

The name originates from Rudyard Kipling's book "Kim," a story of an Irish orphan trained for intelligence work. The name stems from the task Kim underwent in which he looked at a tray of stones and gems for a minute. Once the time passed, Kim had to explain what type of stones they were and how many were there. The approach to determine the correct number of stones displayed engages the decision point of the general pattern recognition process.

Just like the Kim's game, snipers use other observational games to dissect, memorize, and perform precisely (Sniper Sustainment Training, n.d.). Sustainment characteristics of Army operations include anticipation, integration, continuity, responsiveness, and improvisation (Logistic Planning, n.d.). The anticipation of remembering the object's descriptions hours later ties to the sustainment characteristic of continuity. Kim's game introduces integration and improvisation, if the sniper forgets an object, then the individual improvises by recalling the surrounding objects around the forgotten object forcing improvisation and integration of other elements from the scenario. Participation in Kim's game increases responsiveness by remembering the objects displayed and forming structured analytic thought process in a manner that allows for later recall (U.S. Army , 1994).

The following excerpt describes a sample game scenario in the context of military training:

> ...they would put different objects on the table: a bullet, a paper clip, a bottle top, a pen, a piece of paper with something written on it-10 to 20 items. You'd gather around and they'd give you, say, a minute to look at everything. Then you'd have to go back to your table and describe what you saw. You weren't allowed to say "paper clip" or bullet," you'd have to say, like, "silver, metal wire, bent in two oval shapes." They want the Intel guys making the decision [about] what you actually saw. (Valdes, 2011)

As time progresses, the number of items increase and the time lapse between observation and recounting observation also increases. Snipers play the observation portion of the game, go to field training, and then return to describe the items they saw earlier during the observation portion of the game. Sniper trainees describe the objects in Kim's game based on the following categories: *size, shape, condition, color, and appears to be* (Sniper Sustainment Training, n.d.). Sniper trainers introduce an element of real-world applicability by occasionally introducing distractions (noise or talking) or simply different methods of introducing the objects.

Simulation-Based Training

SBT is a method for presenting instructional training using a simulated platform (Martin, Hughes, Schatz, & Nicholson, 2010). SBT has developed as a response to the gap created between traditional classroom and live training. In traditional classroom instruction, an instructor dispenses information through PowerPoint or comparable programs. Unlike the classroom approach, SBT creates training exercises where the trainee can assess their acquired skills (Lyons, Schmorrow, Cohn, & Lackey, 2002; Oser, Cannon-Bowers, & Dwyer, 1999).

The use of SBT as a mode of instruction helps to enhance perceptual training skills and improve higher-order functioning (Nicholson & Schatz, 2010). For this research endeavor,

developing perceptual skills namely pattern recognition skills, is imperative to human behavior cue detection training (Carroll, Milham, & Champney, 2009). The ability to observe, analyze, and compare behavioral changes to indicate suspicious intent is crucial to understanding the area of operation (e.g., probable enemy intent, civil affairs issues, and personalities) (Fischer & Geiwetz, 1996). This research initiative incorporates SBT platforms using VEs to present combat profiling training.

Advancements in computer graphics allow simulations to have complex, well-designed realistic scenarios. Scenario-based Training (SbT) involves presenting instructional information to Soldiers before operational deployment in efforts to sharpen their skills. This experiment introduces Kim's game as an instructional strategy for enhancing behavior cue detection skills. The military continues to use SbT for several reasons including cost-effectiveness, safe environment, efficiency, and convenience (Salas, Priest, Wilson, & Burke, 2006). Additionally, the skills taught and practiced using SbT using a virtual environment has shown to extend training transfer to the operational environment (Grant & Galanis, 2009).

Virtual Environments

VEs allow individuals to explore and interact within computer-generated worlds or immersive environments. The concept of a VE has recently made its way into headlines during the past few years, but it originated in 1960's. According to Mazuryk and Gervautz (1996), Morton Heilig created a multi-sensory simulator called the "Sensorama" between 1960 and 1962. This was the first attempt to build a Virtual Reality (VR) system with all the features of the environment; however, it was not interactive. Due to technological advancements, VEs have evolved over the years for use as a trainer to assess perceptual skills applied to SBT. Caldwell and Stinchfield (2011) employed the Virtual Battlespace 2 (VBS2) trainer to evaluate performance on a change detection

task. The results suggest that the virtual trainer produced significant improvement in detection rates, usability, and decline of false-alarm rates over time.

The use of immersive simulations allows an individual the opportunity to be "transported" into a simulated environment. Realistic training environments provide trainees with an opportunity to enhance field skills. The U.S. Military utilizes immersive environments to train Soldiers (Pleban & Salter, 2001; Knerr, 2007). Training sites comprise of immersive systems, which include projector display, cameras, and audio speakers. Immersive environments have the advantage over live training as it allows for modeling live or fictionalized environments based on specific needs. In addition, immersive environments reduce the training times, unlike live environments where operation costs surmount quickly (Loomis, Blascovich, & Beall, 1999; Bowman & Hodges, 1997).

Immersive simulations also have limitations. One disadvantage is the inability to perform physical tasks such as touching a person or grasping an object. An individual's perception does not match reality and may negatively affect performance. Another disadvantage is associated with sustainment cost of immersive systems. Immersive simulations need additional care to upkeep the computers systems running efficiently and on-call technical support for scenario implementation.

When comparing PC-based systems to immersive environments, there have been several debates as to which training system is effective for training across all domains (Bowman & McMahan, 2007). PC-based systems afford the trainee to engage in learning from a learner-centered approach (Slater, 1999). A learner centered approach focuses on simulated tasks adopted from real-world situation where the trainee enhances learning skills and self-awareness. One major benefit of the learner-centered approach allows for individualized, self-regulated learning on a PC system. As a result, Soldiers are able to develop information-processing skills, and enhance higher order skills anywhere due to the accessibility of the PC.

Another benefit of PC systems look towards research conducted by Ortiz, Maraj, Salcedo, Lackey, and Hudson (2013), demonstrating that a standard desktop system is capable of generating greater engagement than an immersive portable system due to the disparity of simulated Field Of View (FOV). Individuals felt greater levels of engagement while using a PC-based system to complete a detection task. Past research supports the use of PC-based system for pattern recognition training of human behavior cues. In order to assess the effectiveness of pattern recognition training on performance, it is important to examine measures of perception such as Engagement, Flow, and Working Memory.

Engagement

Bangert-Drowns and Pyke (2002) define Engagement as a combination of cognitive, affective, and motivational strategies that promote involvement in a task. Engagement demonstrates a key role in cognitive processes such as memory (Brandimonte & Passolunghi, 1994); higher order perceptual skills including interpretation, evaluation, problem solving (Antonacci & Modaress, 2005), and achievement (Lee & Smith, 1995) VEs are one of many computer-generated environments designed to simulate real-world situations. According to Garris (2002) and Ellinger (2004), researchers are in the early stages of understanding the relationship that link instructional strategy using computer-generated environments, motivational processes, and learning outcomes. Motivational components such as engagement and immersion influence computer-based learning, which ultimately affect learning outcomes (Martens, Gulikers, & Bastiaens, 2004). This experiment seeks to employ a modified version of Kim's game to determine if there is a difference in Engagement between the Kim's game group and the control group. Further, this experiment hypothesizes that there is a strong, positive correlation between Engagement and performance.

Flow

Jackson, Martin, and Eklund (2008) describe Flow as a state where an individual is absorbed in a task and is unaware of their surroundings. A reivew of the literature reveals that the impact of Flow on task performance has not been directly assessed. Inferences from the work of Csikszentmihalyi (1988) suggest that Flow is experienced when there is a balance between changes and the skills to complete a task. Flow results as the outcome if the balance is acheved at a high level of performance. Thus, indivuals who score high on Flow should correlate highly with scores on the performance measure. This assuption has been supported recently by Weibel, Striker and Wissmath (2011) in an e-learning environment where students who scored higher on the Flow survey had higher test scores. This research hypothesizes that Flow should enhance performance due to customized training the kim's game group receive compared to the control group. Another related hypothesis suggest that there will be a strong, positive relationship between Flow and performance.

Working Memory

The Operation Span Test (OSPAN) developed by Turner and Engle (1989) and later modified by Matthews (1999) is developed to assess the effects of WM on performance. Performance on WM tasks depend on mutiple factors such as the impact of the cognitive subsystem on chunking, rehearsing, and storing information before the executive control system makes the final decision. WM predicts performance of higher-order cognitive skills utilizing the OSPAN Test (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999). Previous research have shown OSPAN test to have good test-retest reliability (Klein & Fiss, 1999) and internal consistency for WM capacity (Conway, Cowan, Bunting, Therriault, & Minkoff, 2002; Engle, Tuholski, Laughlin, & Conway, 1999; Klein & Fiss, 1999). Further, WM

contributes to explaining individual-differences and accounts for variability in intellectual capacity. This research experiment hypothesizes that there is difference in WM outcomes for the Kim's game group compared to the control group. Additionally, there will be strong, positive relationship between WM and performance.

Proposed Study

The purpose of this research is to understand the impact of SBT for ISR tasks. Specifically, this experiment focuses on pattern recognition training for behavior cue detection analysis. The objective for this experiment is to assess the effectiveness of the Kim's game methodology compared to the control group by evaluating differences in performance outcomes between those who participate in the game and those who do not. Further, the goal is to apply the Kim's game instructional strategy to a VE in efforts to assess human behavior detection skills. The following research hypotheses intent to provide insight into pattern recognition training by comparing a simulated version of Kim's game to the control group:

H1: There is a significant difference in post-test performance between Kim's game group and the control group

H2: There is a significant difference in Engagement, Flow, and Simulator Sickness after the practice scenario between Kim's game group and the control group

H3: There is a relationship between Engagement, Flow, Simulator Sickness, and post-test performance as well as a relationship between WM and practice performance

H4: Engagement, Flow, and Simulator Sickness as a predictor of post-test performance

CHAPTER 3: METHODOLOGY

Experimental Design

This experiment followed a between-groups design with one independent variable—SBT instructional strategy. The instructional strategy applied Kim's game to a VE for detecting kinesic cues. Kim's game practice vignette was generated using video capturing software to create each instance for comparison. The results were compared the control condition.

Independent Variable

Experimental Condition

The experimental condition applied Kim's game instructional strategy to identify target cues amongst non-target cues in a Culturally Agnostic Urban terrain. The experimental condition comprised of Kim's game as a discrete task that was approximately 35 minutes long. The results were compared to the control group to assess differences in performance and perceptions.

Control Condition

Expanding on the instructional strategies for scenario-based research conducted by Salcedo (2014), the Mass Exposure (ME) condition was assigned to the control condition for this experiment. ME doubles the signal probability ratio (2:3) which improves target detection accuracy and threat saliency (Mogg & Bradley, 1999; Salcedo, 2014) comparable to the probability ratio for the kim's game condition. The ME results was compared to the Kim's game condition to determine the impact on performance.

Dependent Variables

The dependent variables comprised of performance and survey data collected from analysis. Performance data assessed objective measures regarding the participant's performance on the task, while survey data measured the participant's perception of their performance within the VE.

Performance Data

Detection Accuracy Scores

Detection accuracy scores were based on the number of targets stimuli correctly identified within the vignette expressed as a percentage. The percentage was determined by the number of correctly identified targets divided by the total number of targets within each vignette.

False Positive Detection

False positive detection identified a non-target model depicting a target behavior cue. Identification of false positive non-target cues and model types were calculated to determine any correlations between cue or model type and false positive detection.

Response Time

Response time was determined by the amount of time a participant reacts to an event that appears on the screen, either clicking the target to detect a match or selecting the no change icon to indicate no match. The time was measured in seconds.

OSPAN

The OSPAN is computerized test that requires participants to solve 24 problems, each comprising of a mathematical problem and word recall component. The mathematical problem is

a straightforward calculation such as "(3+3) – 1 = 5." Participants are required to press the computer spacebar only if the answer is correct. The word recall element contains high frequency concrete noun (e.g., Soldier) displayed in capital letters above the mathematical problem. Each problem was presented for 1.8 seconds with an inter-item interval of 0.2 seconds. After a set of six items are displayed, the participant is prompted to type in the order either the six first letters or the six last letters of the noun. Participants have 15 seconds to complete each set of six problems (Turner & Engle, 1989; Matthews , et al., 1999).

Survey Data

Demographics Questionnaire

The Demographics Questionnaire (APPENDIX B: DEMOGRAPHICS QUESTIONNARE) collected biographical data on the participant's age, sex, education, military experience, video game experience, etc.

Engagement Measure

The Engagement Measure (APPENDIX C: ENGAGEMENT MEASURE) consisted of seven questions with a rating scale from 1 to 5 (i.e., strongly disagree to strongly agree) for analysis and was used to assess the level of involvement a participant feels while immersed in the vignette. (Charlton & Danforth, 2005).

Flow State Short Scale

The Flow State Short Scale (APPENDIX D: FLOW STATE SHORT SCALE) comprised of nine questions with a 1 to 5 rating scale (i.e., strongly disagree to strongly agree). Flow gauged

the participant's mental state of "being in the zone" while participating in the VE (Jackson, Martin, & Eklund, 2008).

Simulator Sickness Questionnaire

The Simulator Sickness Questionnaire (SSQ) (APPENDIX E: SIMULATOR SICKNESS QUESTIONNAIRE) was used to assess any physical symptoms a participant experienced while exposed to the VE. SSQ symptoms include general discomfort, fatigue, headache, etc. Each participant rated the symptoms as "None," "Slight," "Moderate," or "Severe" (Kennedy, Lane, Berbaum, & Lilienthal, 1993).

Participants

A power-analysis determined that approximately 36 volunteers needed to participate in the Kim's game experimental condition. The control condition comprised of 39 participants for data analysis. For data collection, a flyer containing general information about the study was distributed using various media outlets (e.g., University of Central Florida [UCF] psychology email, word-of-mouth, and on the Institute for Simulation and Training [IST] website). Participants were asked to sign-up through the UCF Psychology SONA system or UCF-IST SONA System website. The two websites are not affiliated or contracted with any parties for personal or organizational gain. Participants were compensated monetarily or with class credit for their participation. The rate of pay was ten U.S. dollars per hour or one credit per hour of participation for a maximum of 5 hours.

In order to participate within this experiment, participants met certain inclusion/exclusion criterion. The participant could not have participated in a subsequent series of experiments under the simulation training research in virtual environments study. Each participant was 18 years or

older, a U.S. citizen, and have normal or corrected to normal vision (e.g., glasses or contacts) to participate.

Before the start of each experimental session, the researcher asked a series of pre-experimental questions for cross-reference during the analyses to explain any inconsistencies that may affect the performance data. Information collected include consumption of alcohol, sedatives, and anti-depressants within the past 24 hours. Additionally, the pre-experimental questions will be used for future analysis in upcoming related experiments and was not used as an exclusion criterion for this experiment. Please see pre experiment questionnaire (APPENDIX A: PRE EXPERIMENT QUESTIONNAIRE) for a more detailed description of the pre-experimental checklist of questions asked of the participant.

Experimental Testbed

A 22-inch standard desktop computer with a 16:10 aspect ratio presented the scenario tasks within the VBS2 platform. Currently, VBS2 is a used by the U.S. Army for creating game-based training using VEs (VBS2, 2014). Keeping with the Army's current training platform, VBS2 created scenarios utilizing Kim's game for pattern recognition training (Figure 9)

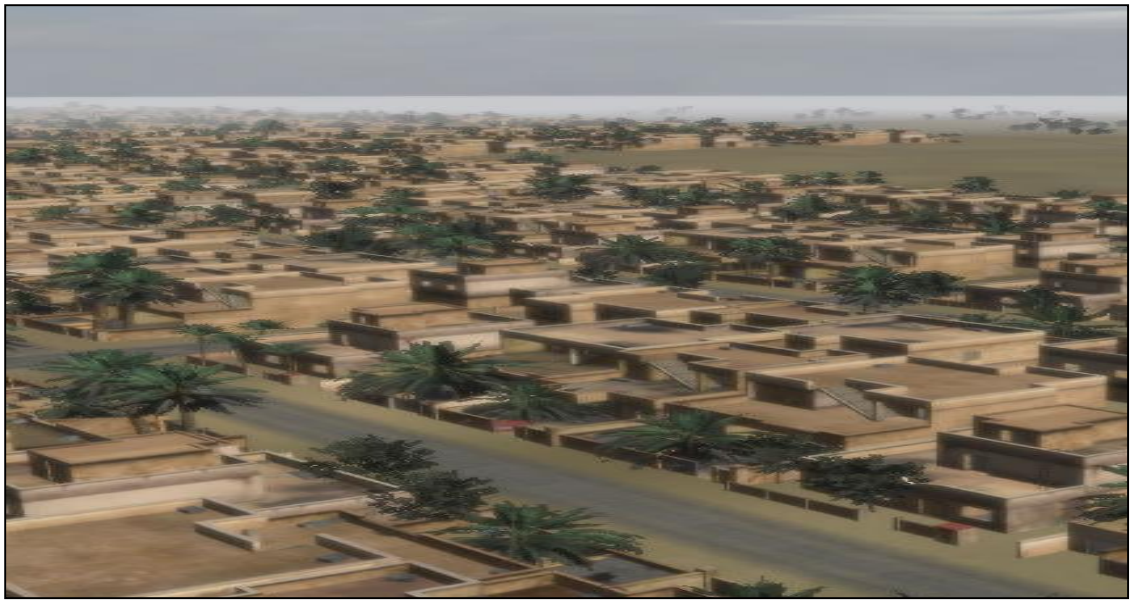

Figure 9: VBS2 Testbed

Experimental Terrain

For experimentation, the terrain selected to present the training and practice scenarios consists of the Culturally Agnostic Urban environment (Lackey, Salcedo, & Hudson, 2013). This geographic terrain was selected because it focuses on the projected future state of warfare. Additionally, the Culturally Agnostic Urban scenarios include features such as buildings, objects, vehicles, and geo-typical terrains. When compared to other terrains such as the marketplace and suburban, the urban environment is less crowded and allows for greater attention to the models. Further, in order to reduce any potential confounds and keep in line with the research objectives, the urban environment support models with various skin tones and allows for greater spacing between virtual models for detecting behavior cues.

Virtual Models

The target models utilized in this experiment was developed using Autodesk MotionBuilder software. The software created behavioral cue animation for target models

imported into VBS2. The non-target models was selected from the current VBS2 animation catalog for display in the VE. Targets and non-targets represented as virtual models in the experimental scenarios comprised of different skin tones including fair, light, and dark (Fitzpatrick, 1988; Lackey, Badillo-Urquiola, & Ortiz, 2014) for both males and females.

Virtual Camera

The proposed camera display mounts onto an Unmanned Ground System, providing a first-person view of environment on a 16:10 monitor. The advantages of using VBS2's customizable camera allowed for standard viewing, restricted speed, and control of the FOV. For experimental purposes, this created a measure of control when viewing the VE. Each participant viewed the display binocularly where the virtual camera had a stationary height of three feet above land surface that travelled 1.5 meters per second (m/s) (Mykoniatis, Angelopoulou, Soyler, Kincaid, & Hancock, 2012; MARCbot, 2010).

Behavioral Cues

Previous research conducted by Salcedo (2014) on kinesics identified four target and non-target behavior model cues (Table 1) for representation within the VE. The Kinesic domain provide virtual characters with sufficient dynamic movement that offered the least number of limitations for virtual representation when compared to the other combat profiling training domains (e.g., proxemics, biometrics, etc.). The four non-targets cues displayed in the scenarios serve as distractors. The experimental scenario comprised of virtual models that display target and non-target cues.

Table 1: Target and Non-Target behavioral cues. Adapted from (Salcedo, 2014)

	Kinesic Behavior Cue	**Description**	**Classification**
Target	Slap Hands	The back of one hand strikes the palm of the other hand.	Aggressiveness
	Clench Fists	Fingers are curled and squeezed into the palms.	Aggressiveness
	Wring Hands	Fingers and palm of one hand clasp the opposite hand and rub along the fingers.	Nervousness
	Check Six	The head turns to look over the shoulder followed by the body turning around 180º.	Nervousness
Non-Target	Idle Talking	Conversational behavior indicated by subtle hand and arm gestures.	N/A
	Check "watch"	Head angles down and one arm is raised slightly as if checking the time on a watch.	
	Cross Arms	Arms are bent at the elbows and overlap each other across the front of the body.	
	Rub Neck	Palm and fingers of one hand rubs the side of the neck	

While both target and non-target model cues are portrayed in the VE, only one target cue is presented as either aggressive or nervous. Due to the novelty of this research endeavor, one target cue will exhibit a change or show no-change among the group of target and non-target models. The number of models presented in each group was determined by the work of Benenson, Nicholson, Waite, Roy, and Simpson (2001) on competitive behaviors showing that groups of four elicit more of a competitive nature as opposed to groups of smaller sizes. With a larger group size, there is a greater propensity to display signs of aggressive behavior than smaller groups. Eastin (2007) supports this assertion with significant positive correlations found between larger group sizes associated with increased signs of aggression. Often times, in real-world situations, if there is an aggressive individual in the group then other members typically exhibit nervous behaviors. In this research experiment, four virtual models comprised of a group where one model displayed the targeted cue while the other three models exhibited non-target cues.

Kim's Game Task Layout

Applying the general concept of Kim's game to observe and remember details within a VE, this experimental task required the participant to detect a change in the pattern of behavior in the Culturally Agnostics Urban environment by clicking on a target if a match is observed or selecting the no change icon if no match existed. The decision time allotted for determining a match after the event occurs was based on STM research (Peterson, 1966; Downing, 2000); however, it was modified to fit the Kim's game task. Applying pattern recognition research to change detection and piloting a sample of participants established a duration of 8 secs for each event. This experiment determined event 1a as 8secs, then 1sec ISI (blank screen), followed by event 1b appearing for 8 secs was sufficient time to represent one scene. Table 2 is an example of the Kim's game task layout.

Table 2: Kim's Game Task Layout

Event	**Position A**	**Position B**	**Position C**	**Position D**	**Time**
Start Time					1sec
1a	N	N	N	N	8secs
Blank Screen					1sec
1b	T	N	N	N	8secs
End Time					1sec
Change Detected Y/N Yes: Click on Stimulus; No: Click No Change					20secs

Unlike the practice vignette, the pre/post-test scenarios were continuous tasks that simulated real-world dynamic environment. Presenting the pre/post-test as continuous scenarios allowed for greater control thus allowing the results to be generalizable and increasing practical

significance. The pre-test scenario required participants to detect kinesic cues by clicking on virtual models that exhibited these cues based on previous experience or perception of aggressive or nervous cues. The pre-test described the participant's knowledge (baseline) before exposure to the training scenarios. The scenario gave the participant an opportunity to scan the scene and detect virtual agents who were exhibiting kinesic behavior cues. The scenario was approximately 40 minutes long with no blank scenes to separate the baseline and changes in the environment. The post-test was presented after the final practice scenario and identical to the pre-test, however the route is reversed.

Event Trigger Layout

The VBS2 camera started traveling at a speed of 1.5 m/s where an event was triggered every two seconds (or 12 meters). Placement of each model was determined by the close phase in Hall's (1990) research on social distance, suggesting that each model be placed one meter apart from the center point. The placement of each group (i.e., left and right) was presented on each side of the roadway within the VE (Figure 10) to ensure consistent viewing of each model. Furthermore, the distance between the first and second group is 9 meters. Each model activated and displayed a pre-assigned animation determined by a random number generator. Collectively, the group of eight models activated to become event 1a. After the black screen appeared, the second group of eight models that appeared become event 1b. This continued throughout the timed practice scenario.

To reduce order effects, the number of groups on the left and right that appeared to be "closer" to the camera were balanced. The participant's view of the model's position and angle within the VE were determined by the model's point of origin, either the left or the right foot. Each model's point of origin was one meter away from the imaginary center point. The center

point was anchored in the middle of the scenario and was approximately two meters from the road.

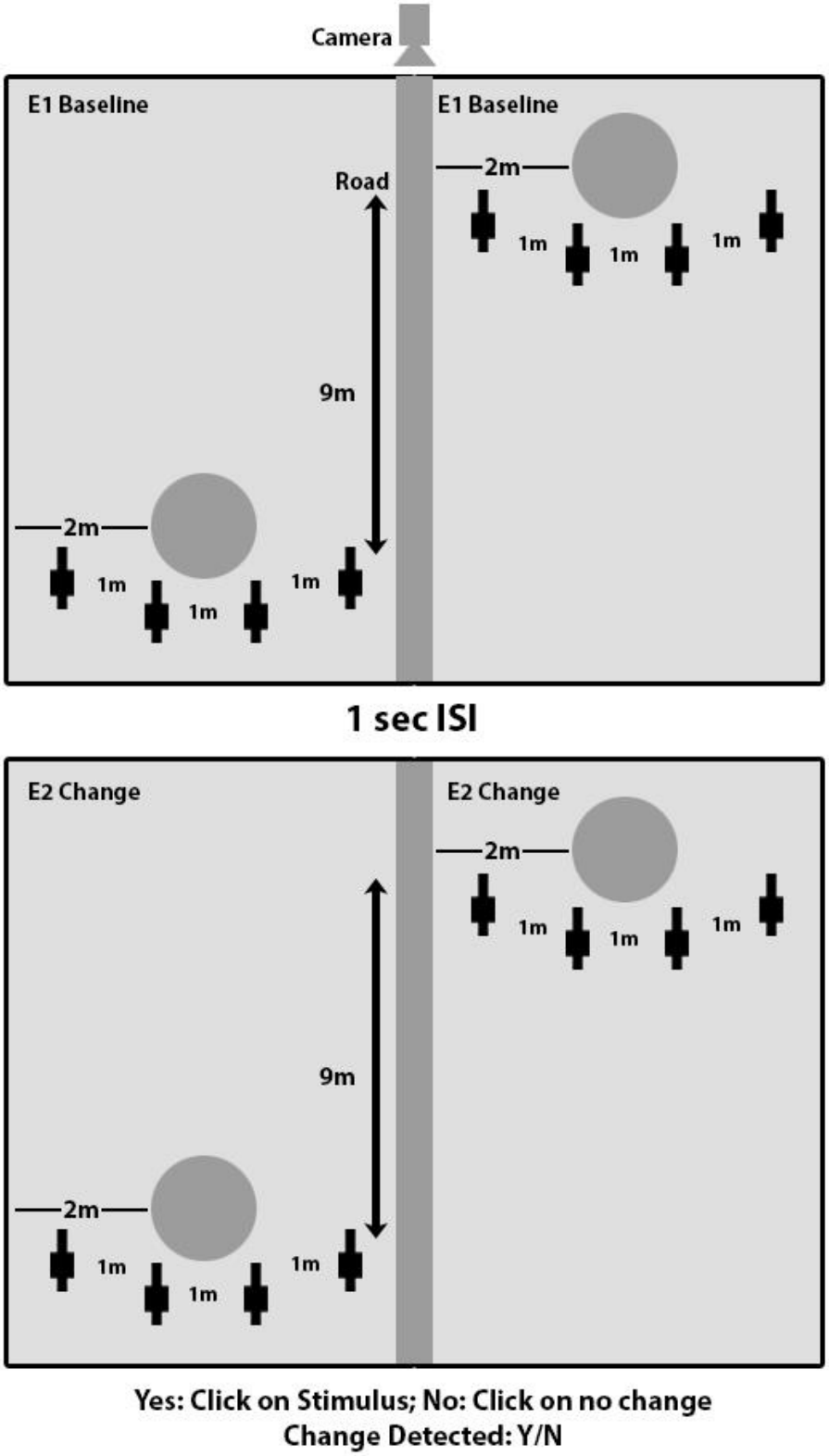

Figure 10: Event Trigger Layout

Calculations for Practice Videos

Table 3 lists the steps used to explain the calculations for the Kim's game practice videos in the Culturally Agnostic Urban environment. The six different model types (i.e., Males: fair, light, and dark; Females: fair, light, and dark) were multiplied by the 4 different non-target cue types (Table 1), equaling 24 target cue and model combinations. The 24 combinations were multiplied by 8 positions (i.e., A, B, C, B, E, F, G, and H), equaling 192 instances for event 1a (no-change). Event 1b (change) was determined using a conditional probability to explain possible changes. Therefore, 1b (change) was obtained given that 1a (no-change) occurred. Thus, 192 was multiplied by 4 possible target changes equaling 768 possible change combinations.

Table 3: Calculations for Kim's game practice video

Practice Video	
6	different model types
x 4	different non-target types
= 24	non-target cue and model combinations
x 8	positions (A through H)
= 192	instances for event 1a non-target changes
x 4	possible target changes
= 768	event 1b possible change combinations

The calculations for the practice videos created a series of video clips. Each video clip contained event 1a, ISI (blank screen), event 1b, then the final decision. Table 4 lists the calculations for the length of each video clip equaling 39secs. In 60secs (or 1min), 1 complete video clip was shown, multiplied by 50 video clips to determine the total length of the completed practice video. The duration of the practice video was 32mins and 50secs, close to the appropriate range (20-30mins) for maintaining vigilance of a discrimination task (See, Howe, Warm, & Dember, 1995; Caggiano & Parasuraman, 2004). Utilizing 50 video clips allowed for balancing and equal representation of the 8 positions and 4 targets. By applying the 2:3 event rate,

approximately 32 videos clips had a target change, while approximately 18 did not experience a change (Mogg & Bradley, 1999). The target and non-target videos were randomized prior to experimentation in order to minimize presentation effects on the participants.

Table 4: Calculations for video clip length

Video Clip	
1sec	before clip starts
+ 8secs	1a
+ 1sec	interstimulus interval
+ 8secs	1b
+ 1sec	video processing time
+ 20secs	decision
= 39secs	video

Calculations for Pre/Post-Test

Targets and Non-Targets

The pre-and post-test targets (Table 5) comprised of 12 different model types from the culturally agnostic urban environment with 1 males and 1 female of each skin tone: fair, light and dark as well as the middle eastern urban environment with 6 males of medium skin tones. The 12 model types were multiplied by 4 different target cues types, resulted in 48 target cue and model combinations. This combination (48) was multiplied by 4 positions per event equaling 192 total targets. The total number of targets (192) was multiplied by 3 (event rate) resulting in 576 total events. The total number of events was then multiplied by the 4 models per event, which was equivalent to 2304 total models per scenario. Finally, the total number of targets (192) was subtracted from the total number of models per scenario (2304) equaling to 2112 non-targets.

Non-Target Cues

The pre-and post-test non-target cues (Table 5) comprised of all 12 different models multiplied by 4 non-target cues equaling 48 non-target cue and model combinations. The non-target total (2112) was divided by 4 positions to give 528 non-targets per position. The non-targets per position total (528) was then divided by 48 non-target combinations equaling 11 non-target combinations per position.

Table 5: Calculations for Pre/Post-Test Targets, Non-Targets, and Non-Target cues

Pre/Post Targets and Non-Targets		**Pre/Post Non-Target Cues**	
12	different model types	12	different models
x 4	different target are types	x 4	non-target cues
= 48	target cue and model combinations	= 48	non-target cue and model combos
x 4	positions per event	528	non-targets per position
= 192	total events	$4\sqrt{2112}$	non-target total positions
x 3	event rate	11	each non-target combo
= 576	total events	$48\sqrt{528}$	non-target per position
x 4	models per event		
=2304	total models		
-192	targets		
=2112	non-targets		

Procedure

Upon arrival at the research laboratory, the experimenter verified that the participant was scheduled for the experiment. In the designated lab space, the experimenter administered the informed consent and required the participant to sign the informed consent. The experimenter also signed the informed consent to acknowledge the participant's willingness to participate. Subsequently, the experimenter asked a series of pre-experimental questions, and then administer the Ishihara Test for Color Blindness. If the participant was unable to pass the colorblindness test, the experimenter had instructions for dismissal. If the participant successfully passed the color

blindness test, then the experimenter asked the participant to complete the demographics questionnaire and OSPAN test.

The experimenter then presented the first interface training on the computer. The interface training scenario provided the participant with an opportunity to practice the navigation and detection techniques, within the environment needed to complete the pre-and post-test. The participant needed to score over 75% in order to continue the experiment. If the participant was unable to achieve a passing score, then the experimenter had instructions for re-administering the interface training.

If the participant achieved over 75% passing score on the second attempt, the participant completed a pre-test scenario. The pre-test scenario required the participant to identify targets that appear to be aggressive or nervous. The scenario was continuous and lasted up to 40 minutes long. After the pre-test scenario was completed, the experimenter advised the participant to complete a second interface training directed towards the experimental scenarios to follow.

The second interface training presented a discrete task for pattern recognition training. The first scene presented with groups of four barrels followed by a blank screen, and then re-introduce the scene with changes in the color of one or none of the barrels. The participant is required to detect if a change has occured by clicking on the desired target or selecting the no change icon if there was no changes in the groups of barrels. The scenario was approximately two minutes long. Successful completion of the task required a 75% score or more to continue the experiment. If the participant was unable to achieve the passing score, the experimenter had instructions for re-administering the interface training. Once the participant successfully complete the discrete task, the experimenter informed the participant to complete the SSQ followed by a five-minute break.

The experimenter presented the kinesic training slides that contained photo examples of human models depicting the target behavior cues. Following the PowerPoint presentation, the experimenter administered the practice vignette. The vignette lasted approximately 17 minutes. The participant completed the scenario followed by the Engagement survey, Flow questionnaire, and SSQ.

The participant had a 5-minute break. After the break, the experimenter presented a brief PowerPoint on the post-test interface training followed by administering the post-test scenario. The post-test scenario lasted up to 40 minutes. The participant then completed the SSQ. Finally, the experimenter debriefed and dismissed the participant. Table 6 lists the experimental procedure with an expected completion of up to 3 hours.

Table 6: Experimental Procedure

List of Experimental Procedure
Participant reads and acknowledges participation from Informed Consent
Administer pre-experiment questions, Ishihara Test for Color Blindness
Administer Questionnaires: Demographics, OSPAN
First Interface Training slides/ Training Scenario (Pass/Fail)
Pre-Test Scenario
Second Interface Training slides/Training Scenario (Pass/Fail)
Administer Questionnaire: SSQ
Break (5 minutes)
PowerPoint Training
Practice Vignette
Administer Questionnaires: Engagement, Flow, and SSQ
Break (5 minutes)
Post-Test Interface Training slides
Post-Test Scenario
Administer Questionnaire: SSQ
Debrief and dismissal

CHAPTER 4: RESULTS

Preliminary Data Analyses

The biographical data analyzed from the experiment revealed *n*=75 participants with 34 males and 41 females; ages ranged from 18 to 38 (*M*=22.27, *SD*=3.75). Descriptive statistics were performed to test the assumptions of normality, homogeneity of variance, and the existence of any outliers of the performance and survey data for Kim's game and control groups. The following variables (i.e., post-test detection accuracy, false positive detection, Engagement, Flow, and Simulator Sickness for Kim's game and control group) violated the test for normality. However, the data remained untransformed because of the large sample size (n>30 for each condition) and the "robustness" associated with the parametric test for analysis (Fields, 2009; Glass, Peckham, & Sanders, 1972).

Cronbach's alpha determined the reliability of the experimental questionnaires (i.e., Engagement, Flow, and SSQ) for both the Kim's game and control groups. The analyses revealed a low reliability statistic (α=.3) for the Engagement measure. A review of the Item-Total Statistics table determined that Engagement measure item three (APPENDIX C: ENGAGEMENT MEASURE) would be deleted and the Cronbach's alpha was recalculated. The result showed deleting item three increased the overall Cronbach's alpha. Table 7 list the Cronbach's alpha for the Engagement measure as well as the other experimental questionnaires.

Table 7: Reliability Analysis for Survey Data

Survey	**Cronbach's Alpha (α)**
Engagement	.6
Flow	.6
Simulator Sickness	.9

Performance Analyses

Pre-Test Performance

An Analysis of Variance (ANOVA) was performed to determine if there were significant differences in performance between the Kim's game group and control group. Specifically, a one-way between-groups ANOVA was conducted to compare the pre-test detection accuracy between the Kim's game group and control group. There was a statistically significant difference in pre-test detection accuracy at the $p<.05$ for the two groups: F (1, 74) =12.06, p=.001. The effect size was large between the two groups (.14) which accounted for the total variability in detection accuracy scores. Individual's pre-test detection accuracy was higher in the Kim's game group (M=58.68, SD=19.96) than the control group (M=44.59, SD=14.99). Additionally, there was a statistically significant difference in pre-test Median Response Time between the Kim's game group and control group at the $p<.05$ for the two groups: F (1, 73) =11.11, p=.001. The effect size was also large between groups (.13) for variability in response time. The Kim's game group (M=5.98, SD=.94) had a marginally faster response time than the control group (M=6.70, SD=.89) in the pre-test scenario. Finally, there was no statistically significant difference in pre-test false positive detection between the two groups.

Post-Test Performance

A series of one-way between-groups ANOVA was conducted to assess the post-test performance between Kim's game and the control group. There were no statistical significance in post-test performance between the Kim's game and control group.

Percent Change

Due to a lack of statistical significance in post-test performance, ANOVAs for percent change (Table 8) were calculated to determine the success of the Kim's game and control intervention. The decrease in response time percentage (approximately 11%) was greater for individuals in the control group (*M*=-15.12, *SE*=1.55) than the Kim's game group (*M*=-3.21, *SE*=2.00), *F* (1, 73) =22.61, *p*<.05. Although, the percent change was not statistically significant for detection accuracy and false positive detection, there is practical significant for the results of each intervention. The increase in detection accuracy percentage (approximately 295%), was greater in the control group than the Kim's game group. Finally, the decrease in false positive detection percentage (approximately 1.5%) was greater in the Kim's game group than the control group.

Table 8: ANOVAs for Percent Change

Percent Change	**Kim's Game Intervention**		**Control Intervention**				
	M	*SE*	*M*	*SE*	*F*	*p*	*η*
Response Time Change	-3.210	2.000	-15.120	1.550	22.610	.000*	.263

*p<.05

Kim's Game: Pre-Test vs. Post-Test Performance

A paired samples-test examined the effectiveness of Kim's game and control strategies on pre- and post-test performance. In Table 9 results show the Kim's game intervention. There was a mean increase in detection accuracy scores by 25% from pre- to post-test. Additionally, there was a mean decrease in false positive detection of 492 non-target cues from pre-to post- test

performance. There was also a mean difference in response time of .26 seconds from pre- to post-test performance.

Table 9: Paired Samples T-test for Kim's Game

	Pre-test		**Post-test**						
Outcome	*M*	*SD*	*M*	*SD*	*n*	95% CI	*r*	*t*	*df*
Detection Accuracy	58.68	19.96	83.59	9.07	36	-30.75, -19.08	.51*	-8.67*	35
False Positive Detection	600.17	442.88	108.92	333.08	36	316.92, 665.58	.14*	5.72*	35
Response Time	5.98	.94	5.72	.63	36	.03, .50	.67*	2.28*	35

Detection Accuracy p = .000
False Positives p = .000
Response Time p < .05

Control: Pre-Test vs. Post-Test Performance

Table 10 lists the paired samples t-test results for the control intervention. The results showed a mean increase in accuracy scores by 37 % from pre- to post-test performance. There was a mean decrease in false positive detection of 384 non-target cues from pre-to post- test performance. The response time from pre- to post-test performance had a mean decrease of 1.08 seconds.

Table 10: Paired Samples T-test for control group

	Pre-test		**Post-test**						
Outcome	*M*	*SD*	*M*	*SD*	*n*	95% CI	*r*	*t*	*df*
Detection Accuracy	44.59	14.99	81.2	15.36	39	-41.73, -31.48	.46*	-14.46*	38
False Positive Detection	455.03	241.53	71.74	200.15	39	292.70,473.87	.21*	8.57*	38
Response Time	6.69	.89	5.61	.52	39	.82, 1.33	.48*	8.50*	38

Detection Accuracy p = .000
False Positives p = .000
Response Time p = .000

Engagement Performance

A one-way between-groups ANOVA revealed no statistically significant difference in Engagement between Kim's game and control groups after the practice scenario.

Flow Performance

A one-way between-groups ANOVA was conducted to assess the difference in Flow between the Kim's game and control group after the practice scenario. Table 11 lists the results of the Flow survey subscales. Within the Flow survey, the Action Awareness Merging subscale was statistically significant at the $p<.05$ between the Kim's game and control groups: F (1, 73) =4.92, p=.03. The effect size was a medium between the two groups (.06) which accounted for the variability in the subscale. Individuals in the control group (M=3.44, SD=1.10) experienced greater Action Awareness Merging than the Kim's game group (M=2.89 SD=1.04). Additionally, there was a statistically significant difference in the Clear Goals subscale at the $p<.05$ between the Kim's game and control groups: F (1, 73) =4.11, p=.05. The effect size was small between the two groups (.05) accounting for the variability of Clear Goals. Clear Goals was better understood in the control group (M=4.08, SD=.70) than the Kim's game group (M=3.75, SD=.69). In addition to Action Awareness Merging and Clear Goals, Transformation Of Time was also statistically significant at the $p<.05$ between the two groups: F (1, 73) =6.28, p=.01. The effect size was large between the two groups (.08) accounting for the variability in Transformation Of Time. Transformation Of Time was reported higher in the control group (M=3.69, SD=1.00) than the Kim's game group (M=3.06, SD=1.09).

Table 11: ANOVA's for Flow between Kim's game and control groups

Flow	**Kim's Game Group**		**Control Group**				
	M	*SD*	*M*	*SD*	*F(1, 73)*	*p*	η^2
Action Awareness Merging	2.89	1.04	3.44	1.10	4.92	.03*	.063
Clear Goals	3.75	.69	4.08	.70	4.11	.05*	.053
Transformation Of Time	3.06	1.19	3.69	1.00	6.28	.01*	.079

*p<.05

Simulator Sickness Post Practice Performance

A one-way between-groups ANOVA was conducted to assess the difference in Simulator Sickness between the Kim's game and control group. Table 12 illustrates the results of the SSQ after the practice scenario. The overall results from the table suggests that, statistically, individuals experienced higher Simulator Sickness in the Kim game group than the control group after the practice scenario.

Table 12: ANOVA's for SSQ between Kim's game and control groups

SSQ	**Kim's Game Group**		**Control Group**				
	M	*SD*	*M*	*SD*	*F(1, 73)*	*p*	η^2
Nausea	8.28	1.52	2.13	1.20	223.16	.00*	.754
Oculomotor	10.31	3.57	4.31	3.46	54.63	.00*	.428
Disorientation	8.28	1.54	1.62	1.89	277.67	.00*	.792

*p<.001

Survey Analyses: Correlations

Engagement and Post-Test Performance

The survey data and post-test performance were correlated using Spearman's rho because the data set did not fit a normal distribution. Specifically, a series of Spearman's rank correlation coefficients were computed to assess the relationship between Engagement and post-test performance. Table 13 lists the statistically significant relationships between the Engagement survey and post-test performance. The results suggested that there was a weak, positive correlation between the Engagement survey for Total Engagement, More Time in the VE, Buzz Excitement, and post-test detection accuracy. Each variable was statistically significant at the .05 level. Additionally, there was also a weak negative correlation between the Engagement survey for Total Engagement, Buzz Excitement, and false positive detection at the .05 level.

Table 13: Correlations between Engagement and Post-Test performance (*n*=75)

Engagement	**Post-test Detection**	**Post-Test False Positive Detection**
Total	.23*	-.24*
More Time VE	.28*	-.21
Buzz Excitement	.24*	-.25*

*Correlation is significant at the 0.05 level (2-tailed).

The correlation results between Engagement and post-test performance motivated further examination of the relationship between the Kim's game (*n*=36) and control (*n*=39) group's Engagement and their post-test performance. The results showed no statistically relationships between the two groups and post-test performance.

Flow and Post-Test Performance

A series of Spearman's rank correlation coefficients were conducted to examine the relationships between Flow and post-test performance. The resulted suggested a moderate, positive correlation between Flow subscale Concentration Task at Hand and post-test detection accuracy at the .01 level. All other Flow subscales showed no statistically significant relationships.

The lack of significant correlation results between Flow and post-test performance drove an analysis of the relationship between the Kim's game and control groups' Flow and post-test performance. The results showed that the control group (n=39) had a moderate, positive relationship for Flow subscales Challenge Skill Balance (r=.34, p<.05), as well as Concentration Task At Hand (r=.42, p <.01) and post-test detection accuracy. Additionally, the Kim's game group (n=36) reported a moderate, negative correlation for Flow subscale Clear Goals (r=-.34, p <.05) and false positive detection. Finally, the control group (n=39) had a moderate, negative correlation for Transformation Of Time (r=-.36, p <.05) and response time.

Simulator Sickness and Post-Test Performance

A series of Spearman's rank correlation coefficients assessed the relationship between Simulator Sickness and post-test performance. The following table (Table 14) notes the statistically significant relationships between Simulator Sickness and post-test performance. The results suggested a weak, negative correlation between Oculomotor and detection accuracy at the .05 level. Further, there was a weak, positive correlation between Simulator Sickness scales on Nausea and Oculomotor and false positive detection.

Table 14: Correlations between Simulator Sickness and Post-Test Performance (*n*=75)

Simulator Sickness	**Post-test Detection**	**Post-test False Positive Detection**
Nausea	-.17	.25*
Oculomotor	-.24*	.27*

*Correlation is significant at the 0.05 level (2-tailed).

The correlation results between Simulator Sickness and post-test performance led to an exploratory examination of the relationship between the Kim's game and control groups' Simulator Sickness and post-test performances. The correlations revealed that the control group (*n*=39) had a moderate, negative correlation between Nausea (r=-.36, p <.05) and post-test detection accuracy. Additionally, the control group (*n*=39) had moderate, positive correlations for Nausea (r=.44, p<.01), Oculomotor (r=.47, p<.01), Disorientation (r=.37, p<.05), and false positive detection.

WM and Training Performance

A series of Spearman's rank correlation coefficients were computed to determine the relationship between WM and the practice scenario. The results indicated a moderate, positive relationship between the number of letters the participant left blank (r=.43, p< .01) and response time in the practice scenario.

Survey Analyses: Multiple Linear Regressions

Engagement as a Predictor of Post-Test Performance

To assess Engagement as a predictor of post-test performance, a series of multiple linear regressions were analyzed to interpret the results. The results listed no statistically significant

Engagement items as a predictor of post-test performance. While Engagement does not contain any statistically significant predictors of post-test performance, the largest unique contributors are explained. Of all the Engagement survey items, Spending More Time in the VE (β=.25) had the largest unique contribution to post-test detection accuracy. Additionally, No Use of VE (β=-.24) had the largest unique contribution to post-test false positive detection. Finally, Challenge Of Using the VE (β=.13) had the largest unique contribution to response time.

The lack of statistically significant predictors of Engagement on post-test performance prompted further investigation into Engagement for the Kim's game (*n*=36) and control (*n*=39) groups' as a predictor of post-test performance. However, the multiple linear regression did not produce statistically significant predictors for the Kim's game or control group on post-test performance.

Flow as a Predictor of Post-Test Performance

A series of multiple linear regressions assessed Flow as a predictor of performance. Flow as a predictor of post-test performance did not indicate any statistically significant variables. However, the results indicated the largest unique contributions to post-test performance. Flow state Concentration Task At Hand subscale (β=.36) had the largest unique contribution to post-test detection accuracy. Secondly, Flow state Clear Goals subscale (β=-.31) had the largest unique contribution to post-test false positive detection. Finally, the results suggest that the Flow state Sense of Control subscale (β=.37, $p<.05$) was a statistically significant contributor for post-test response time as well as the largest unique contribution.

Analyses from the multiple linear regression of Flow as a predictor of performance resulted in the assessment of Flow for Kim's game (*n*=36) and control (*n*=39) group' as a predictor of post-

test performance. Nevertheless, the results showed no statistically significant predictors for the Kim's game or control group on post-test performance.

Simulator Sickness as a Predictor of Post-Test Performance

A series of multiple linear regressions examined Simulator Sickness as a predictor of post-test performance. The results found Simulator Sickness as a predictor of post-test detection accuracy and suggested that the Simulator Sickness subscales accounted for 16% of the variance for post-test detection accuracy (R^2=.16, F (3, 71) = 4.64, p<.01). Specifically, Oculomotor (β=1.10, p<.01) and Disorientation (β=-.68, p<.01) were significant predictors of post-test detection accuracy. The largest unique contributor was Disorientation for post-test detection accuracy. Furthermore, the result from multiple linear regression suggested that Nausea (β=.36) was the largest unique contributor to false positive detection. Lastly, Oculomotor (β=.27) was the largest unique contributor to response time.

The multiple linear regression results of Simulator Sickness on post-test performance drove an exploratory analysis of Simulator Sickness for Kim's game (n=36) and control (n=39) groups as a predictor of post-test performance. The results suggested that Disorientation (β =1.01, p<.01) reported by the control's group was a statistically significant predictor for post-test detection accuracy. In addition, the linear regression revealed that Oculomotor (β=.95, p<.05) noted by the control's group was a statistically significant predictor for post-test false positive detection.

CHAPTER 5: DISCUSSION

Performance

This research initiative examined Kim's game as potential strategies for improving pattern recognition training for human behavior cue detection. **H1** was not supported when examining the significant difference in post-test performance between Kim's game and the control group. Next, this research experiment also explored significant differences in Engagement, Flow and Simulator Sickness after completing the practice scenario. The results partially support **H2** for Flow and completely supported for Simulator Sickness between the Kim's game and control group. There was no support for the hypothesis related to the differences in Engagement between the Kim's game and control group. This research also assessed the relationship between Engagement, Flow, Simulator Sickness, and post-test performance, as well as exploring the relationship between WM and practice performance. **H3** was supported for examining the relationship between the Engagement, Flow, Simulator Sickness, WM, and performance. Finally, this research examined Engagement, Flow, and Simulator Sickness as a predictor of post-test performance. **H4** was supported for Simulator Sickness, not for Engagement or Flow. The results from examining **H2, H3, and H4** provide insight into the performance results for the Kim's game and control group. Additionally, the results prompt further investigation into the survey data to help explain the performance results in greater detail. In order to examine these results, it is important to revisit the theoretical constructs to understand the relationships. The following paragraphs expand these relationships to include performance, engagement, flow, simulator sickness and working memory.

The primary performance metric examined in this experiment focused on accuracy. The lack of statistically significant findings for performance allowed for an investigation into percent change for post-test performance. An examination of the percent change for the means did provide insight into the post-test performance between Kim's game and the control group. The results showed that the control group performed better than the Kim's game group in detection accuracy and was a statistically significant for response time. The results of the percent change for the means also suggested that Kim's game had a marginally greater decrease in false positive detection.

One reasonable explanation why the Kim's game group had a greater decrease in false positive detection is that the Kim's game practice scenario focused the participant's attention to the change detection task; therefore, placing emphasis on correctly detecting the target cue. This conclusion drawn support the work by Rensink et al. (1997) on the importance of focused attention to examine a visual change.

The control group practice scenario, on the other hand, may have negatively affected their performance for identifying targets in the post-test scenario. One reason this may have occurred is that the control group training instructions informed each participant that there are *twice as many targets* before completing the practice scenario. The post-test instructions inform the participant to detect targets that appear to exhibit aggressive or nervous kinesics cues. Perhaps, the training instructions carried through to the post-test creating a higher number of false positive detection for the control group. Van Gerven (2003) found that increasing the number of items a person has to attend to in the environment increases complexity, which negatively influences performance. This positive correlation may help explain the high number of false detections for the control group.

An analysis of Kim's game strategy comparing pre- to post-test performance was statistically significant similar to the control strategy pre- to post-test performance. Upon closer inspection of the pre- to post-test performance for each strategy, the results follow a similar trend to the percent change for post-test detection accuracy (control group scored higher) and false positive detection (Kim's game group had a greater decrease). However, the Kim's game group response time from pre-to post-test was significantly less compare to the control group response time from pre-to post-test. A significantly less response time for the Kim's game group may be explained by the time limit imposed for each scene in the practice scenario. Therefore, participant were able to scan the visual scene faster in post-test.

One limitation drawn from the performance results that helps explain why the control performed better than the Kim's game group may stem from similarities between the practice scenario and post-test scenario. Both scenes comprised of a dynamic yet continuous examination of the virtual agents and terrain. Therefore, the practice scenario task may have created a sense of familiarity towards the post-test content. Goss (1953) along with Gibson and Gibson (1955) support this assumption that pre-exposure to stimuli improves the ability to later complete the discrimination task. These findings contribute to understanding the differences in performance. To gain further insight into these differences, it is important to examine the role of Engagement on performance.

Engagement

While there were no statistically significant findings from the Engagement survey to explain practice performance or post-test results, both groups reported feeling some level of engagement. One possible explanation is that the Engagement survey questions focused on

Engagement in relation to the VE experience and less on the individual perception of Engagement while completing the task. This explanation finds support in the lack of high reliability (Cronbach's alpha) of the Engagement survey questions.

Another possible explanation why there were no significant findings for Engagement between Kim's game and the control group is that the Engagement survey may not have been the most appropriate measure for the task. Most studies utilizing the Engagement survey or modified version of the survey are validated using tasks associated with gaming environments (Charlton & Danforth, 2005; Peters & Malesky Jr, 2008). For this research experiment, the Engagement questions may not have been robust to access deeper levels of Engagement. Future research may want to consider a different version of the Engagement measure to examine the real impact on performance.

An examination of the relationship between Engagement and post-test detection accuracy revealed a weak, positive relationship between Total Engagement and post-test detection accuracy, as well as More Time in the VE and post-test detection accuracy. This suggests that as an individual spent more time in the VE, his or her comfort level increases resulting in overall higher levels of Engagement, which positively affected performance. Further, the results indicated a weak, negative correlation between Total Engagement and false positive detection similar to Buzz Of Excitement and false positive detection. These results confirmed individuals were fully absorbed in the post-test detection task, which contributed to fewer mistakes. Additionally, the negative correlation between Buzz Of Excitement and false positive detection may be attributed to practice performing similar tasks earlier in the experiment. As a result, the individual experience increase excitability because of the confidence in making fewer mistakes within the task. Therefore, previous exposure to similar detection tasks improved post-test performance. Finally, a lack of

statistically significant predictors of Engagement on post-test performance may be a consequence of the Engagement survey "not being sensitive" for assessing performance of behavior cue detection. Despite the limited results of Engagement to explain performance, examining the impact of Flow may shed insight into the performance outcomes.

Flow

The results of the Flow survey revealed that the control group experienced higher levels of Action Awareness Merging, Clear Goals, and Transformation Of Time than the Kim's game group after completing the practice scenario. One plausible explanation why the control group exhibited higher levels of Flow may be related to the practice scenario test. The control practice scenario task involved a continuous, uninterrupted sequence of events whereas the Kim's game practice scenario had a discrete task. Time perception may have been impeded by the Kim's game discrete task while the seamless Flow of the control practice scenario created a greater sense of involvement of what to do next while losing track of time. This may help explain why the control group had greater improvement in post-test detection accuracy and response time.

Next, the correlation between Flow and post-test performance was analyzed and the results showed that Flow state Concentration At Task subscale had a moderate, positive relationship to post-test detection accuracy. This research finding suggests that as individuals concentrate on the post-test task, this results in greater detection accuracy. It appears that Concentration At Task promotes focused attention which positively impacts performance. The role of focused attention is necessary for processing selective information while discarding unimportant details or events (LaBerge & Samuels, 1974). Future research is needed to investigate the impact of concentration and focused attention on perception training for behavior cue detection research.

As previously stated, the correlations results suggest that the Flow state Concentration At Task is related to focus attention. These results find greater support from the results of the multiple linear regression. Flow as a predictor of post-test performance revealed Concentration At Task as the largest contributor to post-test detection accuracy. These findings warrant further investigation into focused attention as a specific trait attribute of individual who train to identify human behavior cues. The multiple linear regression also revealed the largest contributor to false positive detection is Clear Goals and response time is Feeling of Total Control. These findings support Flow as a state that fosters improved performance. Thus, Clear Goals and mastery of the task motivated individuals, resulting in improved detection accuracy and response time.

A thorough investigation into the correlations between the Kim's game and control group's Flow and post-test performance suggested that the control group drove the relationship for Flow subscales Challenge Skill Balance, as well as Concentration At Task and post-test detection accuracy. Further, the control group appeared to have higher sense of Flow, which explains the shortened response time within the post-test. The results support the control as an instructional strategy that promotes a higher sense of Flow than Kim's game for training. The lack of concentration At Task for the Kim's game group may be a consequence of flash recognition.

Flash recognition is a technique used by Kim's game that focuses on improving visual memory recall (Godnig, 2003). Greater recall of visual information is largely dependent on the brain's ability to process incoming stimuli both quickly and accurately (LaBerge & Samuels, 1974). In addition, previous research on flash recognition has suggested that the duration of flashing time also affects the recall of information (Soule, 1958). The flash duration of event 1a and 1b in Kim's game appeared for 8 second respectively. Perhaps, the Kim's game group experienced a loss of Flow because the flash duration was too long. The correlations also showed

the Kim's game group reported fewer false positive detection associated with Clear Goals. Clear Goals appears to be a driving force for making fewer mistakes in the post-test. The results suggested that the Flow subscales impact performance. Next, an examination of Simulator Sickness may reveal additional findings that may help to explain the performance outcomes.

Simulator Sickness

An examination of the Simulator Sickness survey revealed that the Kim's game group experienced a higher level of Simulator Sickness than the control group post practice scenario. In addition, the survey results also provided insight into the post-test performance outcomes. One reason why Simulator Sickness was higher for the Kim's game than the control group may be related to the brains ability to process incoming visual information. The human eye processes patterns of information during fixation. Redirecting fixation, also referred to as gaze control, focuses on observing specific perceptual and behavioral activities in a scene (Henderson, 2003). In this research experiment, the Kim's game practice scenario was presented as a series of video clips. The video frame rate was 15 frames per second (or 30 hertz) based on the web standard at the time. The control practice scenario computer display had a refresh rate of 60 hertz. This illustrated that the control had twice as many hertz than the Kim's game video display. This suggest that an individual's gaze in the control practice scenario had clearer perceivable images with 'smooth animations' due to the higher refresh rates than the Kim's game practice scenario video with fewer frame rates. Factors such as frame rate and refresh rate have shown to contribute to Simulator Sickness (Kolasinski, 1995). These factors may explain why the Kim's game and control group experienced symptoms of Simulator Sickness such as eye fatigue, blurred vision, and eye

strain. Because the Kim's game group viewed the video at a lower frame rate, their gaze may have been less steady and increasingly blurry, contributing to higher levels of Simulator Sickness.

The correlations between Simulator Sickness and post-test performance suggest that Simulator Sickness categories Nausea and Oculomotor negatively affected detection accuracy and false positive detection. One possible explanation for increase Simulator Sickness may be associated with the training platform. Oftentimes, VEs provide user discomfort during and after experimental sessions involving the use of a simulated environment (Kolasinski, 1995). Simulated environments such as the VBS2 platform may have negatively influenced the participant experience (e.g., eyestrain, tolerance, discomfort, drowsiness, etc.) of and affected post-test performance for behavior cue detection. Another explanation for the increase in Simulator Sickness may be the length of time exposed to the post-test scenario. The post-test scenario lasted up to 40 minutes to allow for greater experimental control and randomization purposes. Past research has shown that prolonged exposure to high fidelity simulators and virtual interfaces result in perceived adverse physiological states (Kennedy, Stanney, Compton, & Jones, 1999; McGee, 1998). Laboratory research supports exposure time of approximately 30 minutes or more in a VE to induce symptoms of Simulator Sickness in visually dependent tasks (Jaeger & Mourant, 2001).

Finally, Simulator Sickness Oculomotor and Disorientation subscales were statistically significant predictors of post-test performance. Overall, it appears that Simulator Sickness subscales Oculomotor and Disorientation drove detection accuracy performance. Specifically, the results also showed an increase in Disorientation, positively affected detection accuracy while Oculomotor reported by the control group increased false positive detection. These counterintuitive results may be explained by the control groups' familiarization to the post-test scenario coupled with coping cognitive demands of the task, guiding their navigation and

processing of scenario content. Overall, it appears that the Simulator Sickness results drive the problem for lack of statistically significant findings for Engagement and Flow, which ultimately affects performance. Finally, it is important to investigate the role of WM as it impact performance.

Working Memory

An examination of the correlations between working memory and training performance of the Kim's game group revealed that there was a moderate, positive relationship between the number of letters the participant left blank and response time on the practice scenario. The number of letters the participant left blank refers to the sum of how many letters in the sequence recall were left blank in the participants answer from the OSPAN test. The results suggested that the greater number of letters left blank was related to slower response time for detecting targets. The delay in letter recollection and response time may be driven by the role of maintenance rehearsal. Maintenance rehearsal focuses on repeating information (aloud or secretly) for a short period before it is lost. During the OSPAN test, individuals may have engaged in maintenance rehearsal to recall the letters, a similar process engaged to recall the kinesic training cues for identifying targets. This supports why their response time was slower in the practice scenario and further explains why the Kim's game group response time was slower in the post-test performance compared to the control group.

CHAPTER 6: CONCLUSION

This research experiment focused on expanding the body of SBT research by identifying strategies that enhance human behavior cue detection skills. Specifically, this study compared the effectiveness of a virtual version of Kim's game compared to the control instructional strategy by investigating the impact on performance (i.e., detection accuracy, false positive detection, and response time) and survey data (i.e., Engagement, Flow, and Simulator Sickness). This experiment results in five recommendations for the training and education communities, as well as the U.S. Military to consider when selecting effective instructional strategies for behavior cue analysis.

Recommendation #1: The control group outperformed the Kim's game group; therefore, the effort required to develop Kim's game for performance improvement may not be necessary.

Firstly, the control instructional strategy performed better than the virtual version of Kim's game on detection accuracy and response time. The control strategy promotes behavior cue detection by enhancing perceptual skills for increasing visual acuity of target cues. However, the application of this strategy may be better suited for tasks that focus on improving vigilance (e.g., baggage screen or radiology exam) rather than memory recall. The role of Kim's game has significance to behavior cue detection training; but it is not required to improve performance. Instead exploring research topic areas that affect Kim's game pattern recognition training such as flash recognition may be the next step for understanding and advancement of human behavior cue detection research.

Recommendation #2: Kim's game is better suited for reducing false positive detection.

Secondly, the virtual version of Kim's game supports behavior cue detection training by making fewer errors (false positive detection) in detecting kinesic cues. A decline in false positive

detection relates to the Flow subscale Clear Goals. Clear goals drive focused attention and limits distraction, which would reduce errors in detecting kinesic cues. One implication for future research is to examine the impact of Clear Goals for observational and recall tasks in efforts to reduce false positive detection. Additionally, to enhance recall, it is important to examine the concept of maintenance rehearsal applied to WM for identifying target cues in behavior cue detection training.

Recommendation #3: Development of new Engagement metrics that advance with new media and evolving technology.

Additionally, the engagement survey appears to have a gap, which prompts further investigation into the sensitivity of the measure for assessing behavior cue detection. Future design recommendations may benefit from the redesign and validation of a new Engagement survey that focuses on different types of media rather than customized gaming environments. In addition to designing a new Engagement survey, incorporating the use of physiological responses as an objective measure to validate Engagement as well as other survey data is recommended.

Recommendations #4: Delve deeper into the impact of flow by examining user traits, focused attention, and utilization of an expert comparison group.

Next, the control group generally experienced greater Flow than the virtual version of the Kim's game group in performance. This difference in performance requires further investigation into specific user traits. This experiment identifies focus attention as a user trait that warrants further investigation. User trait focused attention is an important characteristic linked to performance, but further research is needed to substantiate focused attention as a user trait for behavior cue detection. Additionally, as behavior cue detection research continues to grow, the

new step would be to consider a planned comparison analysis of experience level (e.g., expert group) to the virtual version of Kim's game performance and survey data.

Recommendation #5: Consider the impact of VE displays to create new methods to reduce simulator sickness for behavior cue detection training.

Lastly, the Kim's game and control group both reported symptoms of Simulator Sickness while using the VE. Factors that may have contributed to Simulator Sickness include VE platform, refresh rate, frame rate, and scene content. These factors contribute to the existing literature on Simulator Sickness; but also serve as the foundation upon which future investigation of VE displays affect behavior cue analysis. These findings support the need to explore novel ways to mediate Simulator Sickness when using VEs for pattern recognition training. For instance, one way to improve technology effectiveness for future training systems is to increase the frame rates for the virtual version of the Kim's game strategy before research experimentation.

Overall, the research initiative has identified key features of Kim's game that are valuable. The virtual version of Kim's game is one of many training tools that is dependent upon the performance metrics used. The implementation of VEs to present behavior cue analysis training is vital. The research findings from this experiment suggest that it is important to reduce false positive detection. Therefore, in situations where Soldiers are scanning a visual scene, making fewer mistakes can result in saving lives, not just of the Soldiers, but those around them as well.

APPENDIX A: PRE EXPERIMENT QUESTIONNAIRE

Note to Experimenters: An answer of "No" to one or more of the following three questions must result it immediate dismissal from participation.	
Are you a U.S. citizen?	Yes No
Are you between 18 and 40 years of age?	Yes No
Do you have normal or corrected to normal vision?	Yes No

Note to Experimenters: The following questions do not contribute to exclusion criteria.	
Have you had any caffeine in the last 2 hours?	Yes No
Have you had any nicotine in the last 2 hours?	Yes No
Have you had any alcohol in the last 24 hours?	Yes No
Have you has any aspirin, Tylenol, or similar medications in the last 24 hours?	Yes No
Have you had any sedatives or tranquilizers in the last 24 hours?	Yes No
Have you had any anti-depressants or anti-psychotics in the last 24 hours?	Yes No
Have you had any antihistamines or decongestants in the last 24 hours?	Yes No
Approximately how many hours did you sleep last night?	

Note to Experimenters: The following handedness questions do not contribute to exclusion criteria.	
Do you have any impairment of your dominant arm or hand?	Yes No
Are you right handed?	Yes No
Which hand do you use to write with?	Left Right Either
Which hand do you use to throw a ball?	Left Right Either
Which hand do you hold a toothbrush with?	Left Right Either
Which hand holds a knife when you cut things?	Left Right Either
Which hand holds a hammer when you nail things?	Left Right Either

Note to Experimenters: For participants to be included in the study, they must identify at least 10 out of the 12 color plates to pass.	Pass?
Ishihara Color Blindness Test	Yes No

APPENDIX B: DEMOGRAPHICS QUESTIONNARE

Age: _____

1. **Sex:** (Circle one) FEMALE MALE

2. **Which is your predominate hand?** (Circle one) RIGHT LEFT

3. **Are you color blind?** (Circle one) YES NO

4. **Do you have normal/corrected vision?** (Circle one) YES NO
   If YES, are you wearing corrected lenses now? (Circle one) YES NO

5. **Are you in your usual state of health?** (Circle one) YES NO
   If NO, briefly explain:
   _____

6. **Approximately, how many hours of sleep did you get last night?**
   _____

7. **What is your major?** (If applicable)
   _____

8. **Have you ever served in the military or ROTC?** (Circle one) YES NO
   If YES, when and/or what branch?
   _____

9. **What is your occupation?**
   _____

10. **What is your highest level of education completed?** (Circle one)
    High School or equivalent Less than 4 yrs of college Completed 4 yrs of college
    More than 4 yrs of college Other: -
    _____

11. **When did you use computers in your education?** (Circle all that apply)
    Grade School Jr. High High School Technical School College Did Not Use

12. **Please estimate the number of hours you use a computer per week** (If none, write "0"):
    _____

13. **Where do you currently use a computer?** (Circle all that apply)
    Home Work Library Other:_____ Do Not Use

14. **How would you describe your degree of comfort with computer use?** (Circle one)
Poor Fair Average Above average Proficient

15. **For each of the following questions, circle the response that best describes you.**
How often do you:
Use a mouse? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use a joystick? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use a keyboard? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use a touchscreen? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use a game controller? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use icon-based program/software? Daily, Weekly, Monthly, Once every few months, Rarely, Never

Use graphics/drawing features in software programs?
Daily, Weekly, Monthly, Once every few months, Rarely, Never
Use email? Daily, Weekly, Monthly, Once every few months, Rarely, Never
Operate radio/remote controlled vehicle/device (e.g., RC car, boat, or plane)?
Daily, Weekly, Monthly, Once every few months, Rarely, Never
Play computer/video games? Daily, Weekly, Monthly, Once every few months, Rarely, Never

16. **Please estimate the number of hours you play video games per week** (If none, write "0"):_____
If you play video games, which types of games do you play? (Circle all that apply)
First-person shooters Strategy Sports Racing Other: _____

APPENDIX C: ENGAGEMENT MEASURE

Instructions: For each statement, circle the number that indicates how much you agree or disagree with the statement.

1. It would not matter to me if I never use a virtual environment for behavior cue detection training in again.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

2. I felt happy at the thought of using a virtual environment for behavior cue detection training.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

3. The less I have to do with using a virtual environment for behavior cue detection training, the better.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

4. I want to spend more time using a virtual environment for behavior cue detection training.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

5. It was important to me to be good at behavior cue detection.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

6. I experienced a “buzz of excitement” while using the virtual environment for behavior cue detection training.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

7. I like the challenge that using a virtual environment for behavior cue detection training provided.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

8. I was interested in seeing how the scenario events would progress.

1	2	3	4	5

Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

9. I was in suspense about whether I would perform well or not in the scenarios.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

10. I sometimes found myself to become so involved with the scenarios that I wanted to speak to the scenarios directly.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

11. I enjoyed the graphics and imagery of the scenarios.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

12. I enjoyed completing the scenarios.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

13. I was unaware of what was happening around me.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

14. I feel that I tried my best during the scenarios.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

15. The scenarios were challenging.

1	2	3	4	5
Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

APPENDIX D: FLOW STATE SHORT SCALE

Instructions: Please respond to the following statements in relation to your experience with this activity. Each statement relates to the thoughts and feelings you may have experienced. Think about how you felt during the scenario and respond by circling the number for how much you agree or disagree with each statement.

During the scenario:	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
1. I felt I was competent enough to meet the high demands of the situation.	1	2	3	4	5
2. I did things spontaneously and automatically without having to think.	1	2	3	4	5
3. I had a strong sense of what I wanted to do.	1	2	3	4	5
4. I had a good idea about how well I was doing, while I was performing the task.	1	2	3	4	5
5. I was completely focused on the task at hand.	1	2	3	4	5
6. I had a feeling of total control over what I was doing.	1	2	3	4	5
7. I was not worried about what others may have been thinking about me or my performance.	1	2	3	4	5
8. The way time passed seemed to be different from normal.	1	2	3	4	5
9. The experience was extremely rewarding.	1	2	3	4	5

APPENDIX E: SIMULATOR SICKNESS QUESTIONNAIRE

Instructions: Please indicate how you feel **right now** in the following areas, by **circling** the word that applies.

1.	General Discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Headache	None	Slight	Moderate	Severe
4.	Eye Strain	None	Slight	Moderate	Severe
5.	Difficulty Focusing	None	Slight	Moderate	Severe
6.	Increased Salivation	None	Slight	Moderate	Severe
7.	Sweating	None	Slight	Moderate	Severe
8.	Nausea	None	Slight	Moderate	Severe
9.	Difficulty Concentrating	None	Slight	Moderate	Severe
10.	Fullness of Head*	None	Slight	Moderate	Severe
11.	Blurred vision	None	Slight	Moderate	Severe
12.	Dizzy (Eyes Open)	None	Slight	Moderate	Severe
13.	Dizzy (Eyes Closed)	None	Slight	Moderate	Severe
14.	Vertigo**	None	Slight	Moderate	Severe
15.	Stomach Awareness***	None	Slight	Moderate	Severe
16.	Burping	None	Slight	Moderate	Severe

*Fullness of head refers to an awareness of pressure in the head.

**Vertigo is a disordered state in which the person or his/her surroundings seem to whirl dizzily. Vertigo is also described as a loss of orientation with respect to vertical or upright positions.

***Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

Are there any other symptoms you are experiencing right now? If so, please describe the symptom(s) and rate its/their severity below. Use the other side if necessary.

APPENDIX F: IRB APPROVAL LETTER

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

Approval of Human Research

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

To: **Stephanie Jane Lackey** and Co-PI: **Crystal Maraj**

Date: **January 06, 2015**

Dear Researcher:

On 01/06/2015 the IRB approved the following modifications to human participant research until 03/23/2015 inclusive:

Type of Review:	IRB Addendum and Modification Request Form Expedited Review Category #7
Modification Type:	A revised study application has been uploaded with the updated Research ID and the study title change from "STRIVE 3: Utilizing Military Training Research in Virtual Environments" to "RAISR: STRIVE 3: Utilizing Military Training Research in Virtual Environments." Florian Jentsch has been removed from the consent document. The sample size has been reduced from 100 to 75 and OSPAN was added to the procedures in the protocol. A revised protocol and receipt has been uploaded in iRIS and a revised Informed Consent document has been approved for use.
Project Title:	RAISR: STRIVE 3: Utilizing Military Training Research in Virtual Environments
Investigator:	Stephanie Jane Lackey
IRB Number:	SBE-14-10058
Funding Agency:	US Army Research Laboratory
Grant Title:	
Research ID:	1056534

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

If continuing review approval is not granted before the expiration date of 03/23/2015, approval of this research expires on that date. When you have completed your research, please submit a Study Closure request in iRIS so that IRB records will be accurate.

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

All data, including signed consent forms if applicable, must be retained and secured per protocol for a minimum of five years (six if HIPAA applies) past the completion of this research. Any links to the identification of participants should be maintained and secured per protocol. Additional requirements may be imposed by your funding agency, your department, or other entities. Access to data is limited to authorized individuals listed as key study personnel.

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

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

Kanielle Chay

IRB Coordinator

LIST OF REFERENCES

Abich, J., Taylor, G., & Reinerman-Jones, L. (2013). Establishing workload manipulations utilizing a simulated environment. *Proceedings of the 8th International Conference of HCI International.* Las Vegas, NV.

Aginsky, V., & Tarr, M. J. (2000). How are differnt properties of a scene encoded in visual memory? *Visual Cognition*, 147-162.

Agostinelli, G., Sherman, S. J., Fazio, R. H., & Hearst, E. S. (1986). Detecting and identfiying change: additions versus deletions. *Journal of Experimental Psychology: Human Perception and Performance*, 445-454.

Antonacci, D., & Modaress, N. (2005). Second life: the educational possibilities of a massively multiplayer virtual world. *Proceedings of EDUCASE Southwest Regional Conference.* Austin, Texas.

Baddeley, A. (1992). Working Memory. *Science*, 556-559.

Baddeley, A. D., & Hitch, G. (1974). Working memory. (G. H. Bower, Ed.) *The psychology of learning and motivation, 8*.

Bangert-Drowns, R. L., & Pyke, C. (2002). Teacher ratings of student engagement with educational software: An exploratory study. *Educational Technology Research and Development, 50*, pp. 23-38.

Barber, D. J., Leontyev, S., Sun, B., Davis, L., Chen , J. Y., & Nicholson, D. (2007). The Mixed-Intiative Experiment (MIX) Testbed for collaborative human robot interactions. *Proceedings of the 2008 International Symposium on Collaborative Technologies and Systems (CTS)*, (pp. 483-489).

Benenson, J. F., Nicholson, C., Waite, A., Roy, R., & Simpson, A. (2001). The Influence of Group Size on Children's Competitive Behavior. *Child Development, 72*(3), 921-928.

Biederman, I. (1987). Recogntion-by-components: A theory of human image understanding. *Psychological Review, 94*, 115-147.

Birdwhistell, R. L. (1970). *Kinesics and context: Essays on body motion communication.* Philadelphia, PA: University of Pennsylvania Press.

Blackmore, S. J., Brelstaff, G., Nelson, K., & Troscianko, T. (1995). Is the richness of our visual world an illusion? Transsaccadic memory for complex scenes. . *Perceptions*, 1075-1081.

Bowman, D. A., & Hodges, L. F. (1997). An evaluation of techniques for grabbing and manipulating remote objects in immersive virtual environments. *In the Proceedings of the 1997 symposium on interactive 3D graphics ACM*, (p. 35).

Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: how much immersion is enough? *Computer, 40*(7), 36-43.

Brandimonte, M. A., & Passolunghi, M. C. (1994). The effect of cue-familiarity, cue-distinctiveness, and retention interval on prospective remembering. *Quarterly Journal of Experimental Psychology: Human Experimental Psychology, 47*, pp. 565-588.

Budde, J. S., & Fahle, M. (1998). The conjunction of features in visual-search tasks. *Perception*.

Bulthoff, H. H., & Edelman, S. (1992). Psychophysical support for a two-dimensional viewinterpolation theory of object recogntion . *Proc. Natl. Acad. Sci.* , 60-64.

Caggiano, D. M., & Parasuraman, R. (2004). *The role of memory representation in the vigilance decrement.* Psychonomic bulletin & review.

Caldwell, J. C., & Stinchfield, M. K. (2011). *Improving Military Change Detection Skills in a Virtual Environment: The Effects of Time, Threat Level, and Tutorials.* Monterey, CA: Master's Thesis.

Carroll, M., Milham, L., & Champney, R. (2009). Military observations: Perceptual skills training strategies. *Proceedings of the Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC)* (p. No. 9287). Arlington, VA: NTSA.

Charlton, J., & Danforth, I. (2005). Distinguishing addiction and high engagement in the context of online game playing. *Computers in Human Behavior, 23*(3), 1531-1548.

Colombo, G., Dolletski-Lazar, R., Coxe, M., & Tarr, R. (2012). Setting the Stage: Preparation for Advanced Combat Profiling Training. In S. Schatz, D. Nicholson, D. Fautua, & E. Reitz (Ed.), *The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC).* Orlando,FL.

Connor, C. E., Egeth, H. E., & Yantis, S. (2004). Visual Attention: Bottom-Up Versus Top-Down. *Current Biology, 14*(19).

Conway, A. R., Cowan, N., Bunting, M. F., Therriault, D. J., & Minkoff, S. R. (2002). A latent variable analysis of working memory capacity, short-term memory capacity, processing speed, and general fluid intelligence. *Intelligence, 30*, 163-183.

Csikszentmihalyi, M. (1988). The flow experience and its significance for human psychology in optimal experience. *Cambridge University Press*, (pp. 15-35). Cambridge, UK.

de Freitas, S. (2006). *Learning in immersiveworlds: a review of game-based learning*. Retrieved from http://www.jisc.ac.uk/media/documents/programmes/

Deaton, J. E., & Parasuraman, R. (1993). Sensory and cognitive vigilance: Effects of age on performance and subjective workload. *Human Performance*, (pp. 71-97).

Department of Defense. (2013). *Defense Budget Priorities And Choices Fiscal Year 2014.* DOD.

Deveau, J., & Seitz , A. R. (2014). Applying perceptual learning to achieve practical changes in vision. *Frontiers in psychology* .

Dolan, R. J. (2002). *Emotion, cognition, and behavior.* Science.

Downing, P. E. (2000). Interactions between visual working memory and selective attention. *Psychological Science, 11*(6), 467-473.

Durlach, P. (2005). Army digital systems and vulnerability to change blindness. *Proceedings of the 24th Army Science* .

Eastin, M. S. (2007). The Influence of Competitive and Cooperative Group Game Play on State Hostility. *Human Communication Research, 33*(4), 450-466.

Ellinger, A. D. (2004). The concept of self-directed learning and its implications for Human resource development. *Advances in Developing Human Resources 6*, 158-178.

Engle, R. W., Tuholski, S. W., Laughlin, J. E., & Conway, A. R. (1999). Working memory, short-term memory and general fluid intelligence: A latent variable approach. *Journal of Experimental Psychology. General*(128), 309-331.

Fadde, P. J. (2009). Inatructional design for advanced leaners: training recogntion skills to hasten expertise. *Educational Technology Research and Development* (pp. 359-376). Springer Link.

Fields, A. (2009). *Discovering Statisitcs Using SPSS.* London: SAGE Publications Inc.

Fischer, S. C., & Geiwetz, J. (1996). *Training Strategies for Tactical Pattern Recognition.* Alexandria, Virginia: United States Army Research Institute for the Behavioral and Social Sciences.

Fitzpatrick, T. B. (1988). The validity and practicality of sun reactive skin types I through VI. *Arch Dermatol, 124*, 869-871.

Garris, R., Ahlers, R., & Driskell, J. E. (2002). Games, motivation, and learning: a research and practice model. *Simulation and Gaming*, (pp. 441-467).

Gibson, J. J., & Gibson, E. J. (1955). Perceptual Learning: Differentiation or Enrichment? *Psychological Review, 62*(1), 32-41.

Gideons, C. D., Padilla, F. M., & Lethin, C. R. (2008, September). Combat Hunter: The training continues. *Marine Corps Gazette, 92*(9), 79-84.

Glass, G. V., Peckham, P. D., & Sanders, J. R. (1972). Consequences of failure to meet the assumptions underlying the use of analysis of variance and covariance. *Review of Educational Research* , 237-288.

Godnig, E. C. (2003). The Tachistoscope Its History & Uses. *Journal of Behavioral Optometry*, 39-42.

Goldstone, R. L. (1994). Influences of categorization on perceptual discrimination. *Journal of Experimental Psychology, 123*(2), 178-200.

Goldstone, R. L. (1998). Perceptual Learning. *Annual Review of Psychology*, 585-612.

Goss, A. (1953). Transfer as a function of type and amount of prelimary experience with task stimuli. *Journal of Experimental Psychology*, 419-427.

Grant , S. C., & Galanis, G. (2009). *Assessment and Prediction of effectiveness of VEs*. Retrieved from pubs.drdc-rddc.gc.ca/BASIS/pcandid/www/engpub/DDW?

Grimes, J. (1996). On the failure to detect changes in scenes across saccades. *Vancouver studies in cognitive science*, 89-110.

Gysen, V., De Graef, P., & Verfaillie, K. (2000). Detection of intrasaccadic changes in stationary and moving objects. *Invest. Ophthalmol. Vis. Sci.* , 41:45.

Hall, E. T. (1990). *The Hidden Dimensions.* Garden City, NY: Random House.

Haque, S., & Srinivasan, S. (2006). A Meta-Analysis of the Training Effectiveness of Virtual Reality Surgical Simulators. *IEEE Transactions On Information Technology In Biomedicine, 10*, pp. 51-58.

Henderson, J. M. (2003). Human gaze control during real-world scene perception. *Trends in cognitive sciences, 7*(11), 498-504.

Hollingworth, A., & Henderson, J. M. (2000). Semantic information mediates the detection of changes in natural scenes. *Vis. Cogn*, 213-235.

Huitt, W. (2003). *The information processing approach to cognition*. Retrieved from Educational Psychology Interactive: http://www.edpsycinteractive.org/topics/cognition/infoproc.html

Jackson, S. A., Martin, A. J., & Eklund, R. C. (2008). Long and short measures of flow: The construct validity of the FSS-2, DFS-2, and new brief counterparts. *Journal of Sport and Exercise Psychology, 30*(5), 561-587.

Jaeger, B. K., & Mourant, R. R. (2001). Comparison of Simlulator sickness using static and dynamic walking simulators . *Proceedings of the Human Factors and Ergonomics Society Annual Meetings* (pp. 1896-1900). SAGE Publications .

Jain, A. K., Duin, R. P., & Mao, J. (2000). Statiistical Pattern Recognition: A Review. *IEEE Transactions on Pattern Analysis and machine intelligence,* (pp. 1-34).

Joint Staff of the Department of Defense. (2013). *The department of defence dictionary of military and associated terms*. Retrieved from http://www.dtic.mil/doctrine/dod dictionary/data/i/4850.html

Kanal, L. (1974). Patterns in pattern recognition:1968-1974. *Information Theory, IEEE*, (pp. 697-722).

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

Kennedy, R. S., Stanney, K. M., Compton, D. E., & Jones, M. B. (1999). Computerized methods to evaluate virtual environment aftereffects. *Proceedings of DSC'99.* Paris, France.

Klein, G. (2008). Naturalistic decision making. *Human Factors: The Journal of the Human Factors and Ergonomics Society*, (pp. 456-460).

Klein, G. A., & Calderwood, R. (1991). Decision models: Some lessons from the field. *Systems, Man and CyberneticS, IEEE Transactions*, (pp. 1018-1026).

Klein, K., & Fiss, W. H. (1999). The reliability and stability of the Turner and Engle working memory task. *Behavior Research Methods, Instruments & Computers, 31*, 429-432.

Knerr, B. W. (2007). *Immersie simulation training for the dismounted soldier.* Orlando, FL: Army Research Institute Field Unit .

Kolasinski, E. M. (1995). *Simulator Sickness in Virtual Environments* . Alexandria, VA: Army Research Institute for the Behavioral and Social Sciences .

LaBerge, D., & Samuels, S. J. (1974). Toward a theory of automatic information processing in reading. *Cognitive psychology*, 293-323.

Lackey, S. J., Salcedo, J. N., & Hudson, I. L. (2013). Assessing performance of behavior cue analysis in simulation-based training environments. *Proceedinds of the Spring Simulation Multiconference.* Orlando Fl.

Lackey, S., Badillo-Urquiola, K., & Ortiz, E. (2014). Research-Driven Recommendations for Implementing Biometric Cues in Virtual Environments. *MODSIM World 2014*. Hampton, VA.

Larson, A. M., & Loschky, L. C. (2009). The contributions of central versus peripheral vision to scene gist recognition. *Journal of Vision, 9*(10), 1-16.

Lee, V. E., & Smith, J. B. (1995). Effects of high school restructuring and size on early gains in achievement and engagement. *Sociology of Education, 68*, pp. 241-270.

Liu, J., Sun, J., & Wang, S. (2006). Pattern recognition: An overview. *IJCSNS International Journal of Computer Science and Network Security, 6*(6), 56-61.

Logistic Planning. (n.d.). Retrieved from Chapter 8: http://www.fas.org/nuke/guide/usa/doctrine/army/fm3-100/CH8.PDF

Loomis, J. M., Blascovich, J. J., & Beall, A. C. (1999). Immersive virtual environment technology as a basic research tool in pschology. *Behavior Research Methods, Instruments, & Computers, 31*(4), 557-564.

Lu, D., Mausel, P., Brondizio, E., & Moran, E. (2010). Change Detection Techniques. *International Journal of Remote Sensing, 25*(12), 2365-2407.

Luck, S. J., & Vogel, E. k. (1997). *The capacity of visual working memory for features and conjunctions.* Nature.

Lund, N. (2009). *Attention and Pattern Recognition.* Retrieved from Pattern Recognition: http://www.slideshare.net/sanzon5/pattern-recognition-2307856

Lyons, D., Schmorrow, D., Cohn, J., & Lackey, S. (2002). Scenario based training with virtual technologies and environments. *Proceedings of the IMAGE 2002 Conference.* Scottsdale, AZ.

MARCbot. (2010). Retrieved from Exponent Engineering and Scientific Consulting: http://www.exponent.com/marcbot_product/

Marr, D., & Nishihara, H. k. (1978). Representation and recognition of the spatial organization of three-dimensional shapes. *Proc. R. Soc.of Lond.* , 269-294.

Martens, R., Gulikers, J., & Bastiaens, T. (2004). The impact of intrinisic motivation on e-learning in authentic computer tasks. *Journal of computer assisted learning*, 368-376.

Martin, Hughes, C. E., Schatz, S., & Nicholson, D. (2010). The Use of Functional L-Systems for Scenario Generation in Serious Games. *Proceedings of the Workshop on Procedural Content Generation in Games* (p. p.No.6). New York, NY: ACM.

Matthews , G., Joyner, L., Gilliland, K., Campbell, S. E., Huggins, J., & Falconer, S. (1999). Validation of a comprehensive stress state questionnaire: Towards a state "Big Three"? *Personality psychology in Europe, 7*, 335-350.

Mazuryk, T., & Gervautz, M. (1996). *Virutal reality-history, applications, technology and future*. Retrieved from http://www.cg.tuwien.ac.at/research/publications/1996/mazuryk-1996-VRH/TR-186-2-96-06Paper.pdf

McGee, M. K. (1998). Using psychophysics to measure negative side effects in immersive virtul environments . *Proceediings of the 42nd Human Factors and Ergonomics Society*, (pp. 1501-1505).

Miclea, D. D., & Opre, A. (2004). The information-processing approach to the human mind: Basics and beyond. *Journal of Clinical Psychology, 60*(4), 353-368. Retrieved from Federal Aviation Administration: http://www.hf.faa.gov/webtraining/Cognition/Information/info_process1.htm

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63*, 81-97.

Mogg, K., & Bradley, B. (1999). Orienting of attention to threatening facial expressions presented under conditions of restricted awareness. *Cognition & Emotion, 13*(6), 713-740.

Mondy, S., & Coltheart, V. (2000). Detection and identification of change in nautralisitic scenes. *Visual Cognition*, 281-296.

Morgan, M. (2003). *Feature analysis.* Handbook of Brain Theory and Neural Networks.

Myers, D. G., & Straub, R. (2007). *Visual Concept Reviews.* Worth Publishers.

Mykoniatis, K., Angelopoulou, A., Soyler, A., Kincaid, P., & Hancock, P. (2012). Modeling and simulation of Human robot interaction: Face recognition implementations. IEEE Intelligent Systems.

Nicholson, D., & Schatz, S. (2010). Making the Implicit Explicit: Operationalizing Tacit Facets of Scenario-Based Training. *Proceedings of the Human Factors and Ergonomics Society 54th Annual Meeting* (pp. 2226-2227). Santa Monica, CA: Sage.

Nicholson, D., Schatz, S., & Bowers, C. (2008). *Developing Adaptive, Intelligent Scenarios to Support Enhanced Operations Training.*

Ortiz, E., Maraj, C., Salcedo, J., Lackey , S., & Hudson, I. (2013). Assessing Engagement in Simulation-Based Training Systems for Virtual Kinesic Cue Detection Training. *HCI International 2013.* Nevada: Springer Link Digital Library.

Oser, R. L., Cannon-Bowers, J. A., & Dwyer, D. J. (1999). Enhancing human performance in technology-rich environments: Guidelines for scenario-based training. *Human/Technology Interaction in Complex Systems*, 175-202.

Palmer, E. M., Fencsik, D. E., Flusberg, S. J., Horowitz, T. S., & Wolfe, J. M. (2011). Signal detection evidence for limited capacity in visual search. *Attention, Perception, & Psychophysics*, *73*(8), 2413-2424.

Pashler, H. (1988). Familiarity and visual change detection . *Perception and Psychphysics* , 369-378.

Pastorino, E., & Doyle-Portillo, S. (2012). *What is Psychology? Essentials.* Cengage Learning.

Pentland, A., & Choudhury, T. (2000). Face recognition for smart environments. *Computer, 33*(2), 50-55.

Perrett, D. I., Oram, M. W., & Ashbridge, E. (1998). Evidence accumulation in cell populations responsive to faces:An account of generalisation of recognition without mental transformation. *Cognition, 67*(1,2), 111-145.

Pessoa, L., & Ungerleider, L. G. (2004). *Neural Correlates of Change Detection and Change Blindness in a Working Memory Task.* Oxford University Press.

Peters, C. S., & Malesky Jr, L. A. (2008). Problematic usage among highly-engaged players of massively multiplayer online role playing games. *Cyber Psychology & Behavior, 11*(4), 481-484.

Peterson, L. R. (1966). *Short-Term Memory.* Scientific American. Retrieved from http://www.indiana.edu/~p1013447/dictionary/stm.htm

Phillips , W. A. (1974). On the distinction between sensory storage and short-term visual memory . *Perception & Psychophysics*, 282-290.

Picard, R. W. (1995). *Affective computing*. Retrieved from http://affect.media.mit.edu/pdfs/95.picard.pdf

Pleban, R. J., & Salter, M. S. (2001). Training and Assessing Decision-Making Skills in a Virtual Environment. *In The Interservice/Industry Training, Simulation & Education.* National Training Systems Association.

Rensink, R. A. (2002). Change detection. *Annu. Rev. Psychol., 53*, 245-277.

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (1997). To see or not to see: the need for attention to perceive changes in scenes. *Psychol. Sci.*, 368-373.

Robert, S., & Baden-Powell, S. S. (1921). *Scouting games.* (Vol. 4). The Scout Library.

Ross, W. A., Bencaz, N., & Militello, L. G. (2010). *Specification and development of an expert model for "Combat Hunters".* U.S. Joint Forces Command.

Salas, E., Priest, H. A., Wilson, K. A., & Burke, C. S. (2006). Scenario-based training: Improving military mission performance and adaptability. *Military lifr: The psychology of serving in peace and combat*, 32-53.

Salcedo, J. (2014, July). Instructional Stratgies for Scenario-Based Training of Human Behavior Cue Detection and Classification with Robot-Aided Intelligence, Surveillance, and Reconnaissance. *Doctoral Dissertation*. Orlando, Fl, U.S.A.

Schatz, S., Reitz, E. A., Nicholson, D., & Fautua, D. (2010). Expanding Combat Hunter: The science and metrics of Border Hunter. *The Interservice/Industry Training, Simulation & Education Conference (I/ITSEC)* (p. 10147). Arlington, VA: NTSA.

See, J. E., Howe, S. R., Warm, J. S., & Dember, W. N. (1995). Meta-analysis of the sensitivity decrement in vigilance. *Psychology Bulletin* , 230.

Selfridge, O. G. (1959). "Pandemonium: A paradigm for learning.". In D. V. Blake, & A. M. Uttley (Ed.), *Proceedings of the Symposium on Mechanization of Thought Processes*, (pp. 511-529). London.

Simons, D. (1996). In sight, out of mind: when object representation fails. *Psychological Science*, 301-305.

Simons, D. J., & Levin, D. T. (1997). Change blindness. *Trends in Cognitive Sciences, 1*(7), 261-267.

Simons, D. J., Franconeri, S. L., & Reimer, R. L. (2000). Change blindness in the absence of a visual disruption. *Perceptions*, 1143-1154.

Sireteanu, R., & Rettenbach, R. (1995). Perceptual learning in visual search: fast, enduring, but non-specific. *Vision research*, 2037-2043.

Slater, M. (1999). Measuring presence: A response to the Witmer ans Singer presence questionnaire. *Presence: Teleoperators and Virtual Environments, 8*(5), 560-565.

Sniper Sustainment Training. (n.d.). Retrieved from Chapter 9: http://www.globalsecurity.org/military/library/policy/army/fm/23-10/Ch9.htm

Soule, R. L. (1958). Flash Recognition Training in Law Enformance Work--Next Exposure Ready Now . *Journal of Criminal Law Criminology & Police Science*, 590.

Spain, R. D., Priest, H. A., & Murphy, J. S. (2012). Current trends in adaptive training with military applications: An Introduction. *Military Psychology, 24*(2), 87.

Steadman, R. H., Coates , W. C., Huang, Y. M., Matevosian, R., Larmon, B. R., McCullough, L., & Ariel, D. (2006). Simulation-based training is superior to problem-based learning for the acquisition of critical assessment and management skills. *Critical Care Medicine, 34*(1), 151-157.

Tarr, M. J., & Vuong, Q. C. (2002). *Visual object recognition* (Vol. 1). (H. Pashler, & S. Yantis, Eds.) New York: Wiley.

Thompson , K. G., Bichot, N. P., & Sato, T. R. (2005). Frontal eye feld activity before visual serach errors reveals the integration of bottom-up and top-down salience. *Journal of Neurophysiology, 93*, 337-351.

Thompson, K. G., Bichot, N. P., & Schall, J. D. (2001). *From attention to action in fontal cortex.* (J. Braun, C. Koch , & J. Davis, Eds.) Cambridge, MA: MIT Press.

Tollner, A. (2006). *Individual and team susceptibility to changeblindness.* Doctoral Dissertation, University of Cincinnati.

Turner, M. L., & Engle, R. W. (1989). Is working memory capacity task dependent? *Journal of Memory and Language, 28*, 127-154.

U.S. Army . (1994). *Sniper Training.* Washington, D.C.: Field Manual No.23-10.

Valdes, R. (2011). *How military snipers work.* Retrieved from How stuff works : http://science.howstuffworks.com/sniper10.htm

Van Gerven , P. W. (2003). The efficiency of multimedia learning into old age. *British journal of educational psychology, 73*(4), 489=505.

Vanderplas, J. M., Sanderson, W. A., & Vanderplas, J. N. (1964). Some task-related determinants of transfer in perceptual learning. *Perceptual and Motor Skills*, 71-80.

VBS2. (2014). *Bohemia Interactive Simulation*. Retrieved from http://products.bisimulations.com/products/vbs2/overview

Vogel-Walcutt, J. J., Gebrim, J. B., Bowers, C., Carper, T. M., & Nicholson, D. (2011). Cogntive load theory vs.constructivist approaches: which best leads to efficient, deep learning? *Journal of Computer Assisted Learning, 27*, 133-145. doi:10.1111/j.1365-2729.2010.00381.x

Weibel, D., Stricker, D., & Wissmath, B. (2011). The use of a virutal learning centre in the context of a university lecture: factors influencing satisfaction and performance. *Interactive Learning Environments.*

Wickens, C. (2002). Multiple resource and performance prediction. *Theor. Issues In Ergon. Sci*, 159-177.

Wolfe , J. M., & Horowitz, T. S. (2004). What attributes guide the deployment of visual attention and how do they do it? *Nature Reviews Neuroscience, 5*, 495-501. doi:10.1038/nrn1411

Wolski, J. (2013). *Computer Modeling and Simulation*. Retrieved from National Institute of Health: www.ors.od.nih.gov/OD/OQM/cms/Pages/default.aspx

Yarbus, A. L. (1967). *Eye Movement and Vision.* New York: Plenum Press.