IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK IN MILITARY APPLICATIONS

by

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A thesis submitted in partial fulfillment of the requirements
for the degree of Master of Science
in the Department of Industrial Engineering and Management Systems
in the College of Engineering and Computer Science
at the University of Central Florida
Orlando, Florida

Summer Term
2007

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ABSTRACT

Humans carry mental models concerning the behaviors, looks, and operation of products, tools, and items used in their daily lives. When these items do not fit a user's conceptual model confusion and inefficiency occur. There are four basic types of mental models based on interactive activities: 1) instructing, 2) conversing, 3) manipulating and navigating, and 4) exploring and browsing. This thesis will focus on the conversing conceptual model and its application to communications between human-agent teams to best fit a user's mental model for that communication.

A non-anthropomorphic framework does not exist for use in military applications such as; target detection, nuclear, biological, and chemical agent detection, and explosive ordinance disposal. As agents become increasingly autonomous and complex in the currently military working environment an effective and un-confusing non-anthropomorphic meta-language framework must be explored and developed to fulfill the need for human-agent communications. The meta-language framework may consist of visual and audio cues as pose, motion, color, and non-speech sounds. This thesis will attempt to identify and evaluate a non-anthropomorphic framework of communications between human-human, human-agents, and agent-agent teams that will maximize the effectiveness of the communications in terms of efficiency and interpretation.

ACKNOWLEDGMENTS

I must acknowledge the person who pushed me harder, encouraged me each day, and provided me more support than any man deserves and that is my wife Lori. Without your love and support this whole process would have much more difficult to say the least. I love you and thank you for everything.

To my kids, Ava and Jack, y'all were observant enough to know when I needed to work and plenty of fun when you knew I needed to play. I love you two more than any father can love his kids because you two were always the perfect distraction and stress relief from a demanding task. Thank you kids, and don't worry I see a trip to Chuck E. Cheese® in your future.

I would like to extended special thanks to my thesis committee members Dr. Randy Shumaker and Dr. Peter Kincaid. Your insight and guidance were always on-time and on-target.

Finally I would like to thank my thesis committee chair, Dr. Michael Proctor. Sir, your professionalism and dedication to a knucklehead like me was astonishing and it never let up. Throughout this process you always pointed me in the right direction and were relentless in extracting the best from me. Sir, I thank you and I hope this product meets your expectations.

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LIST OF ACRONYMS

AAR	After Action Review
AIS	Advanced Interactive Systems
ANOVA	Analysis of Variances
AN/PRC	Army-Navy Portable Radio Component
ASIP	Advanced System Improvement Program
ARI	Army Research Institute
CD/RW	Compact Disc / Re-Writable
CHI^2	Chi-Squared
CI	Confidence Interval
DEM	Demographic Questionnaire
DOD	Department of Defense
FBCB2	Force XXI Battle Command Brigade and Below
FM	Frequency Modulation / Field Manual
GOMS	Goal, Operators, Methods, Strategies
GPS	Global Positioning System
HIP	Human Information Processing
IR	Infrared
ITQ	Immersive Tendencies Questionnaire
LTM	Long-Term Memory
MS	Military Science
PC	Personal Computer

PREF	Preference
SINCGARS	Single Channel Ground and Airborne Radio System
SC	Superior Colliculus
SE	Standard Error
SOP	Standing Operating Procedure
STM	Short-Term Memory
SVS	Soldier Visualization System
ROTC	Reserve Officer Training Corps
TTP	Tactics, Techniques, and Procedures
US	United States

CHAPTER ONE: INTRODUCTION

The military battlefield has become an increasingly complex environment with the additions of technologies, intricate strategies, and the wide variety of operational missions placed upon our military. Compare images of Soldiers from as recent as World War II to Soldiers on today's battlefield and a number of differences will immediately become apparent. In terms of technology, take for instance a Soldier's weapon, over time the weapon has increased its ammunition capacity (in World War II, the M1 Garand rifle had a five round capacity, today's M16 rifle has a 30 round capacity), and it has increased in variety for use (the M1 was only a rifle, today's M16 is a rifle that can be configured with a grenade launcher, shotgun, and a collapsible butt-stock for close quarter combat use). There are other obvious changes from Soldiers of yesteryear to Soldiers of today such as uniforms, insignia, helmets, boots, and combat gear. There are some less obvious changes from Soldier's of the past to those Soldiers fighting in Iraq and Afghanistan today.

1.1 Communications Technology and their Impact upon How Soldiers Fight

Technology has impacted Soldiers in other forms of the way we fight and more specifically the way Soldiers communicate before, during, and after an engagement. There is one aspect of pre-engagement communications that have remained relatively consistent since the days of the Revolutionary War (Roger's Rangers), and that is hand and arm signals. Although the specific movements and their desired meanings have changed, the basic purpose of communicating covertly between team members has not. During the Vietnam era the common tool of communication between units of Soldiers was the AN/PRC-25 and AN/PRC-77. These two man-portable radios weighed approximately 25 pounds with batteries (that lasted 1-2 hours with heavy use), had a range of three to seven miles (depending on terrain), and only operated on a single channel AM net. Today, Soldier's are using the ASIP SINCGARS (Advanced System Improvement Program, Single Channel Ground and Airborne Radio System) that is capable of advanced data transmission, reduced weight (approximately 7 pounds), an anti-jam feature (through the use of frequency hopping along a FM spectrum), and flat panel display/input. The efficient and robust means of communications have enhanced military operations by adding increased lethality to unit performance in any mission. For example the data transmission of fire mission information reduce the call of fire time from observer to fire direction center and significantly reduce human error in the transmission and application of technical firing data to the gun line. In the end overall fire mission processing time is reduced thus enabling a firing unit to fire more missions and provide for a greater of amount of fire support.

Another contribution as a result of the advances in data transmission in communication technologies is global positioning and networking of units within a battle space. FBCB2 (Force XXI Battle Command Brigade and Below, Figure 1) combines the data transmission capabilities found in the ASIP SINCGARS radios with GPS (Global Position System) locating capabilities. This results in an overlay of units and key points of interest upon terrain database with an interface for messaging reports and information between units.

Figure 1: FBCB2 Screen.

The impact of these advanced technologies and their resulting impact upon the way Soldiers fight can be simply summed up: operating and fighting as a Soldier has become significantly more multimodal and the demands upon these modalities are increasing. The combat engagement has always interacted with a user's visual, olfactory, and auditory input modalities, but now with such items as the FBCB2 and its touch-screen interface the haptic modality (though this is only a limited use of haptics) is becoming an integral part of interacting with others and the environment.

1.2 Agents on the Battlefield

In the midst of advances within Soldiers technologies and communications between Soldiers and units there has been the application of robotic agents into the combat environment for a variety of purposes including explosive ordinance disposal and reconnoitering. These robotic agents are not agents in the purest form as they are not autonomous but rather remotely controlled. Interaction and communication between robotic agents and humans is limited as the agents can only interact with few highly trained personnel including the agents' creators (Bruce, Nourbakhsh, and Simmons, 2001). This does pose a serious issue for the use of robotic agents within a military operating environment because with continuous on-going operations the time required to train Soldiers on new pieces of equipment is a precious and limited resource. There is also the issue of complexity in communication as most military training is aimed at the ninth grade level as to ensure its ease in understanding and limit the difficulty involved in assimilating new skills for the un-initiated.

So the issue becomes one of integrating robotic agents into a cohesive human-agent team utilizing communications that build upon the multimodal interfaces of the modern (and future) combat environment while not overburdening the users' input or output modalities. The key idea in the previous statement is not to overburden the user because it can be effectively argued that in life and death situations irrelevant information can hamper performance and clarity of thought. In order to take into account for multimodal information processing a clear understanding of human information processing along with motor response much be accounted for.

1.3 Multimodal Information Processing

The breakthrough concept of working memory and thus the birth of human information processing starting in 1956 with a paper by G.A. Miller in the Psychology Review entitled, *The magical number seven, plus or minus two: Some limits on our capacity for processing information*. This laid the foundation for the human information processing theories that followed as well as theories concerning multimodal information processing. One such concept is encoding, the idea that people learn more than just an object or word, but that the context of that object or word is learned and provides a stronger association for storing and retrieving memories. Other areas of study within human information processing and multimodal processing are resource capacity, working memory, perception, and cognition.

Multimodal information processing appears to be a natural occurrence to humans and even preferred by humans. Take an opportunity to observe a student writing (not taking notes but rather free writing) and often you'll find that individual either talking to themselves or gazing off in the distance as if they are attempting to visualize the subject in which they are writing about. This may have more to do with the way the human brain is structured but it is often case the way humans perceive and think. It also provides for a good example of multimodal information processing, the student is using both auditory and tactile modalities to process information. By using the research provided by the pioneers and experts within the human information processing and multimodal information processing, a communications system can be developed for non-anthropomorphic robotic agents to communicate with human team members without overburdening the input modalities of the human team members.

1.4 Research Significance

As previously stated, it can be effectively argued that in life and death situations irrelevant information can hamper performance and clarity of thought. The concept can be taken further to encompass not only irrelevant information in hampering performance but the inputting of information into a single modality and risking overburdening that particular modality to point of inefficiency. Therefore as robotic agents become increasingly present on the modern and future battlefield it is imperative that a framework for communications is developed to meet the needs of human team members that promote efficiency, are easily interpreted without confusion, and can be successfully learned and trained upon without placing significant demands upon time. Soldiers already perform their wartime mission in multimodal environments, taking advantage of human information processing to efficiently capitalize upon human multimodal capacities is another large step forward in applying technology to the battlefield and making the Soldiers more lethal and efficient.

CHAPTER TWO: THEORETICAL BACKGROUND

To clearly understand what types of signals (visual, audio, haptic, etc.) would provide an ideal means for communications there are several questions that must be answered first: How does the human brain process information? Does the human brain continuously process information or does it flow like waves? Does the human brain process different senses at different rates? Do conceptual models of human-human and human-agent interaction influence perception? What previous research has been conducted in human-agent interaction? The answers to these questions will provide additional insight into human-human and human-agent communications as well gaps in current research.

2.1 The Human Brain

Originating with animal studies it was determined that the site of convergence for multiple modalities was in a place of the brain called the superior colliculus (SC) (Figure 2). The SC is located in the mid-brain and plays a fundamental role in attentive and orientation behaviors (Girad & Peronnet, 1999; Wallace, Meredith, and Stein, 1993). Multi-sensory neurons in the SC receive messages from the three sensory modalities (visual, auditory, somatosensory) which each being represented in the SC by a map of sensory space (Giard & Peronnet, 1999). Each map of sensory space overlaps within the SC so that each individual input modality combine within the SC and corresponds to the original stimulus. In other words, human beings receive stimulus through their input modalities, the brain splits these modalities up and recombines them once again within the superior colliculus. The SC handles multimodal input by increasing the number of impulses through a multiplicative ratio that relates to the multiple inputs (Wallace Wilkinson, and Stein, 1996). In order for the brain to process the inputs cognitively the sensory information is sent to the forebrain for interpretation and organization of behavior (Schneider & Tarshis, 1975).

The way information is initially segregated prior to entering the superior colliculus begs an important question, is information from the separate input modalities processed into the SC at the same or at different rates (speed/time)? Additionally, if the input modalities arrive into the SC at different rates, can these rates be measured?

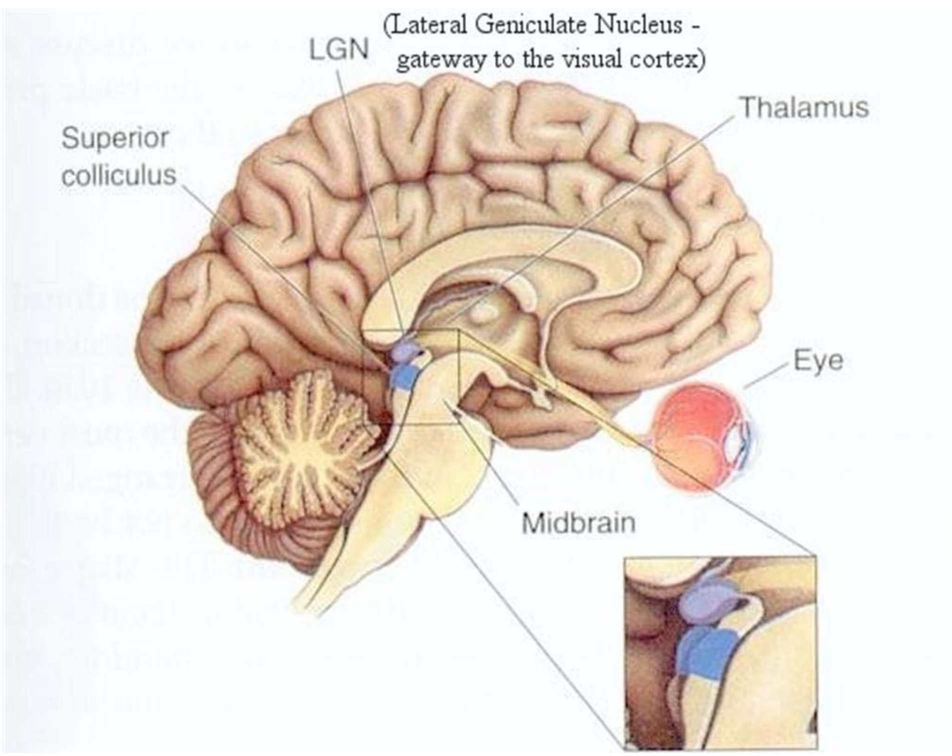

Figure 2: Location of the Superior Colliculus.

2.2 Human Information Processing

The Psychology of Human-Computer Interaction (Card, Moran, and Newell, 1983) began to look at the psychology of the human in its interaction with computers particularly but also measured the time for interaction using the different modalities and processing elements of the human brain (Figure 3). Card et al lay the foundation for the GOMS model (goals, operators, methods, and strategies) and the Human Information Processor. The GOMS model enables researchers to predict human performance for a variety of tasks, mainly computer based by compiling the time the user to complete the perceptual, cognitive, and motor processing. The GOMS model does allow for the comparison of similar tasks through the comparison of total time, but it must be noted that the calculated total time is essentially done in a vacuum. In a vacuum meaning that no outside factors are taken into account such as working environment or emotions of the user. The GOMS model is purely the time to conduct a task. For the purpose of this thesis, that which provides the most insight form Card et al is time decay in working memory for visual and auditory information (chunks) and the time to process for the perceptual, cognitive, and motor processors.

Card et al gives average values for each processing element and additionally the range of time for the ideal and worst case of each processing element, for example:

$$T_p = 100\ [50 \sim 200]\ \text{msec}$$

This would read as the time (perceptual processor, T_p) is 100 milliseconds with a range of 50 milliseconds to 200 milliseconds. The times for processing of the cognitive and motor processors are:

$$T_c = 70\ [25 \sim 170]\ \text{msec}$$

$$T_m = 70\ [30 \sim 100]\ \text{msec}$$

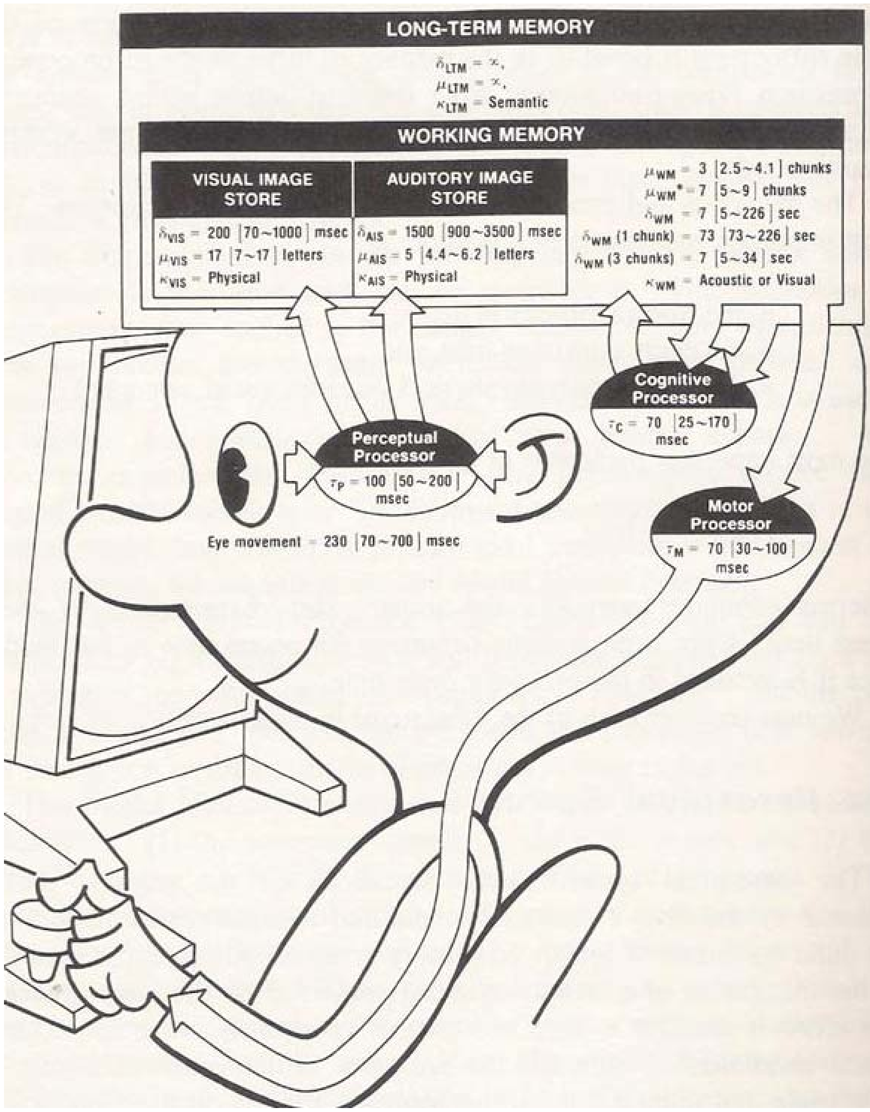

Figure 3: Human Model Processor (Card et al, 1983).

As for the visual/auditory image storage and decay are given as follows;

Visual Image Store: $\mu_{VIS} = 17\ [7 \sim 17]$ Letters

Visual Image Decay: $\delta_{VIS} = 200\ [70 \sim 1000]$ msec

Auditory Image Store: $\mu_{AIS} = 5\ [4.4 \sim 6.2]$ Letters

Auditory Image Decay: $\delta_{AIS} = 1500\ [900 \sim 3500]$ msec

The flow for this particular model begins with the perceptual processor as visual and auditory information is stored into the working memory at rates described above (the information does begin to decay as it is entered into working memory) information in working memory in coupled/matched/used to trigger chunks in the long term memory (LTM) which adds or deletes information in the working memory. In the working memory the cognitive processor engages to problem solve/reason and achieve a solution which is sent to the motor processor for execution. At the fast end of processing with each processor the time would take 115 milliseconds, at the slow end the time would take 470 milliseconds, with an average of 240 milliseconds for processing. A graphical display of simple reaction time analysis for the Model Human Processor is shown in figure 4.

It should be noted that although visual image storage is much higher than auditory storage, auditory information does not decay as rapidly as visual information in short term memory (STM) or working memory. Another significant item of note is where Card et al fall short and that is the inclusion and input of somatosensory information such as haptic input into working memory along with the decay of haptic image storage.

Thus far it would appear to that there are answers to three research questions: How does the human brain process information? Does the human brain continuously process information or does it flow like waves? Does the human brain process different senses at different rates? The human brain processes information in the superior colliculus initially through separate modalities but combines these modalities prior sending the information to the forebrain for processing.

The GOMS model suggests that information is processed continuously as information is continuously presented and not an ebb and flow method of processing. It also appears that information is perceived at different rates along with different rates of decay, but this is only a partial answer and additional somatosensory information is not included in the Card et al model.

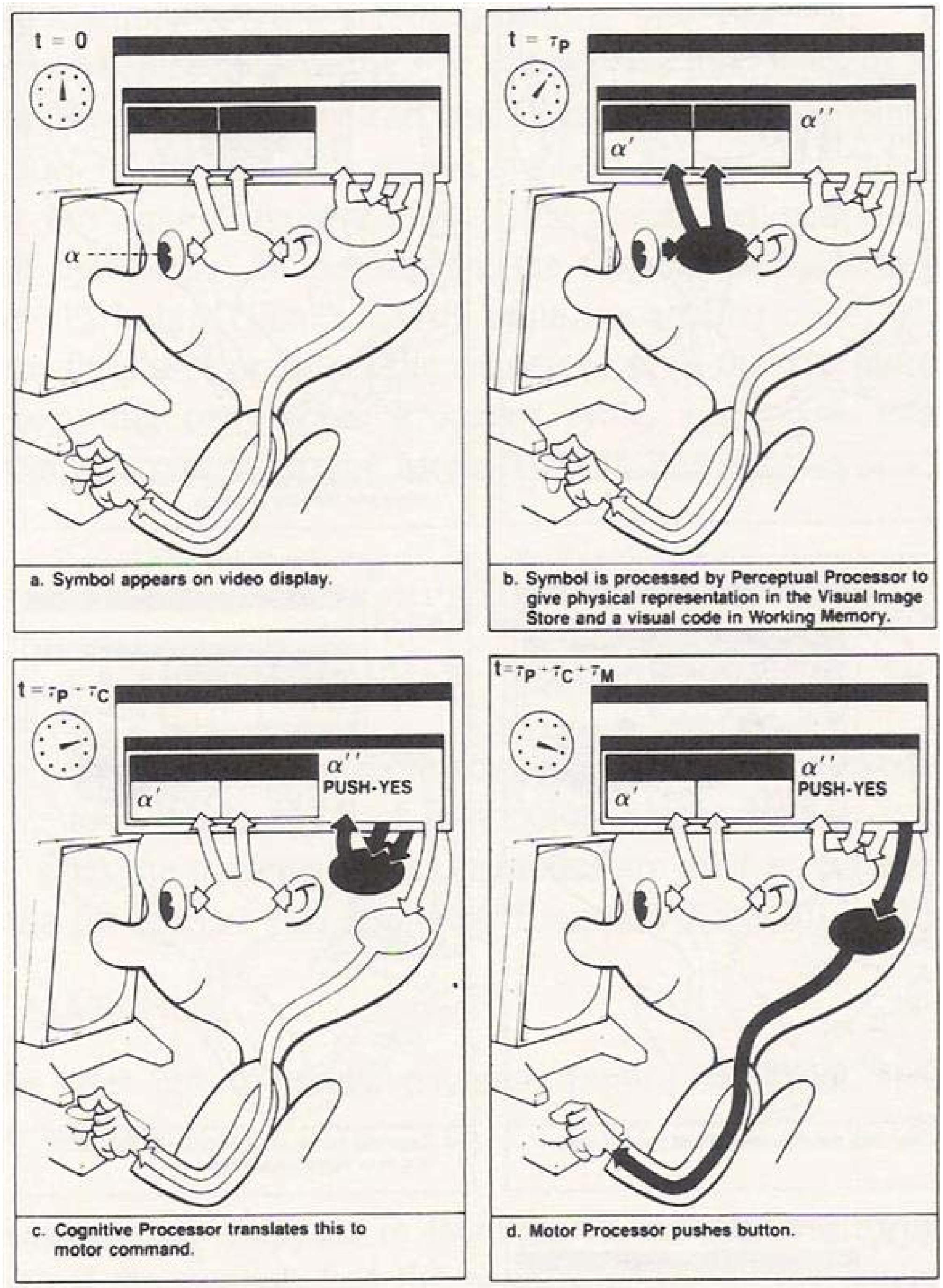

Figure 4: Simple Reaction Time Analysis for the Model Human Processor.

The particular aspect of somatosensory information that is of most importance is haptic information and particularly anything that excites the human sense of touch. Just as there must be an understanding of how the human brain processes input modalities is becomes just as necessary to understand the skin and how it processes haptic inputs. The main difference between the haptic input modality and others (visual or auditory) is that it is not localized; it can be received by any portion of the body. Within the skin are three sensory receptors: thermoreceptors which respond to heat and cold, noiceptors respond to which intense pressure, heat and pain, and mechanoreceptors which respond to pressure (Georgia Tech, 2007). The mechanoreceptors (pressure) is of most importance for this thesis and there are two types of mechanoreceptors: rapidly adapting mechanoreceptors which respond to immediate pressure as applied to the skin (these receptors also respond most quickly respond to increased pressure) and slowly adapting mechanoreceptors which respond to continuously applied pressure. There is another aspect of haptic receptors and it is kinesthesis or the awareness of body position and the positioning of limbs. This mostly affects comfort and performance, such as painter in its relative position to the canvas, how the brush is held, the holding of the palette, and the affect this how on the painter's comfort and performance while painting.

There appears to be a gap on the exact understanding concerning processing times and decay time for haptic input modalities, but there is extensive research concerning haptic image processing. Newell, Woods, Mernagh, and Butloff, 2005 have determined characteristics of haptic image encoding. With regards to a visual scene they are encoded into the brain rather holistically, although recollection of specific details is incomplete, whereas haptic inputs are encoded individually and an entire image is rebuilt over time. This does imply that haptic input modalities are processed serially and not in parallel. This does not give insight into brain processing time for haptic input modalities, but Stanney, Samman, Reeves, Hale, Buff, Bowers, Goldiez, Nicholson, and Lackey, 2004 indicate that although the different input modalities are physically separate they share similar internal structures and properties (e.g. capacity and decay). Figure 5 from Stanney et al, 2004 echoes work from Card et al, 1983 and include the haptic input modality without measured values for capacity and decay although the tactile storage within the inner brain is 3 letters. The human brain's ability to process information from different input modalities and the resultant effect upon overall time to react has significant bearing upon the development of non-anthropomorphic meta-language framework.

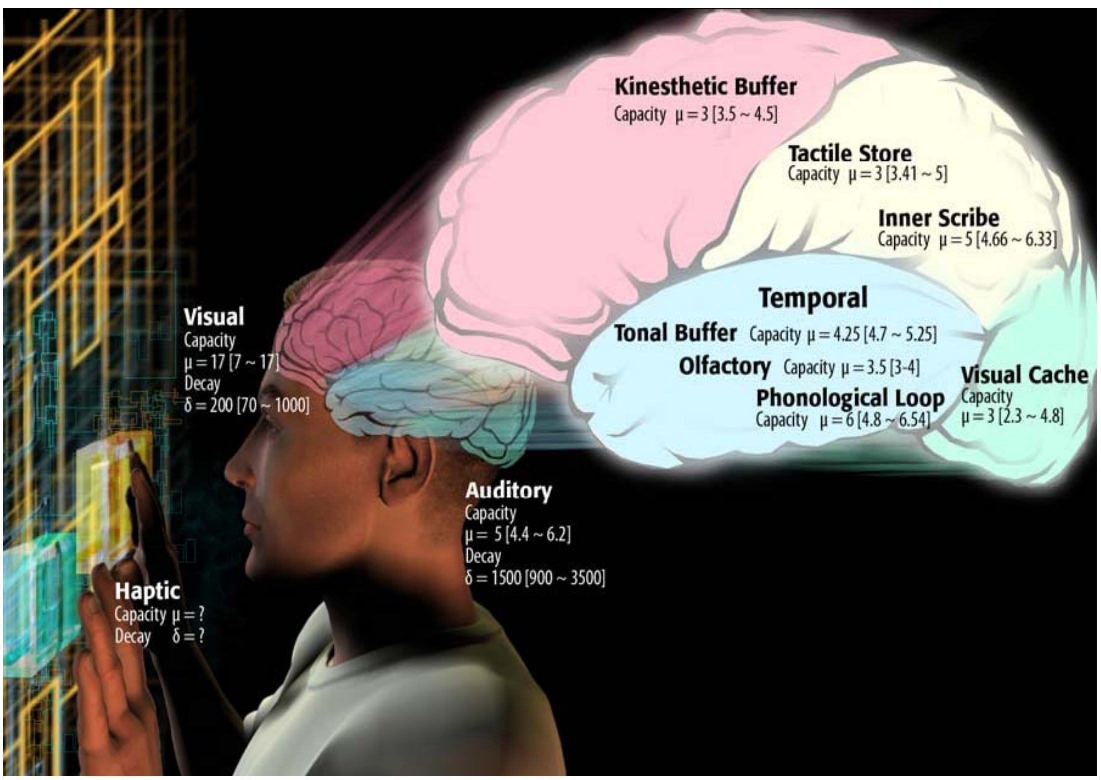

Figure 5: Multimodal Human Model Processor (Stanney et al, 2004).

As previously stated Card et al laid the foundation for human cognition models and have spawned many different models such as: ACT-R, Soar, and EPIC (Anderson & Lebiere, 1998). ACT-R for example builds upon the premise of goal structures and their influence upon knowledge representation.

2.3 Communication Cognition

This section will look to providing additional input into the processing of information by the human brain with special attention to communications. The application of this research is for military operations with the specific impact upon human-agent team communication performance in a combat environment. Veterans of combat operations, this author included, would argue that active direct fire engagement place a significant demand upon the cognitive load of those involved. That being the case it is imperative that communications between members be effective and un-taxing to all members so that each team member is effectively using all cognitive resources throughout the engagement. Wada & Tano, 2000 discovered four approaches in the presentation of information in high cognitive-load environments: 1) presenting information by using real pictures and sounds, 2) use of "background" information, 3) change in "media" and "modality", and 4) adaptation system.

With regard to presenting information by using real pictures and sounds there are two modes by which human cognition can be categorized into: experimental and reflective (Norman, 1994). Experimental cognition is a state where humans react most quickly to situations and perceive most efficiently. Reflective cognition is not quite the opposite but it is the state where humans develop new ideas and solutions to problems. The demand upon cognitive resources is the largest when in the reflective state.

"Background" and "Foreground" information refer to the demand placed upon user attention. An ideal example would be car failures where there appears to be smoke emanating from under the hood. Given that today's vehicles are increasingly more intelligent, the vehicle's display states the window washer fluid is low and the front right tire has low air pressure. That is an example of background information, its information that does not need to demand upon the user's attention. Instead the vehicle should register a check engine light and/or maybe an increase in engine temperature, these would be excellent indicators that the vehicle as immediate issues and the user should turn the vehicle off and seek assistance. That is an example of foreground information, information that places an immediate demand upon user attention to notify, warn, or purely inform. Systems must be careful not to present all information in the foreground as this could potentially overwhelm a user, but conversely not present all information in the background then nothing would be presented that is truly worthy of direct attention. There is a balance point for any given situation; an example of a balance point is a photograph. The subject of the photo are typically upfront and in focus while the remainder of the photograph may be slightly out of focus but is discernable given the right attention. Everything is needed is depicted in the photo yet what you need to know or see immediately is in focus and up front, all other background information can wait until the time or resources can be directed to it.

A change in "media" and "modality" refers to how information is presented to the user by using one or a combination of the five senses (sight, hearing, touch, smell, taste) and to the form of presentation (realistic picture/sound versus an artificial or abstract presentation). The adaptation system refers to the capabilities of individual users. Wada et al uses the analogy of the elderly, who tend to have poor eyesight and difficulties with hearing. This affects their ability to process different input modalities and limits the means and depth of resources the elderly can process simultaneously.

The implications communication cognition has upon the development of a meta-language framework for military applications are as follows: present information that keeps users in the experimental cognition mode to maximize reaction and perception abilities, balance information between the foreground and the background as to not unduly tax a users mental ability, consider changing the pattern and media by which information is presented (e.g. a real picture symbolizes one meaning and a man-made sound another), and finally tailor the communication system to the users. Developing an auditory framework for Artillerymen that use low frequency, low intensity communication cues is not going to get the job done.

2.4 Multimodal Information Processing & Communications

This section looks to explore the concept of multimodal information processing and the implications that could have on a communications framework. Are human beings capable of effectively working in a multimodal environment? The reality is that humans instinctively process the world through multiple modalities. For instance when a car horn is blasted people tend to look in the direction of the sound to encompass the scene holistically through multiple inputs. This is true for simple everyday events such as receiving the news, where people sight newspaper and television individually and together for their source of important news and current events (Graber, 1988). It's interesting to note that 48% of the sampled group read the newspaper and watch televised news (not simultaneously) to gather their information.

There may be two explainable reasons for human preference to multimodal information processing; perceptual integration and redundant-signal effect (O'Hare, 1991, Giard et al, 1999, and Miller, 1982). Perceptual integration is the concept of combining different input modalities into multimodal representation of an object into an amplified form of that object. Redundant-signal effect is the concept of increased reaction time due to redundant bi-modal information processing from separate uni-modal sources. In essence redundant-signal processing enhances human perception and ultimately affects response selection and execution which in turn improves reaction times.

Direct combat is already a multimodal environment consisting of visual and auditory activity of the fight, haptic integration with the shock of explosions and movement along the battlefield, olfactory stimulation with the smells of gunpowder and/or burning items, gustatory effects of fighting with an open mouth and allowing the particles within the air to enter the mouth. It would seem with all the other input modalities of the environment that communications should not only remain focused but that using multiple modalities could be a step towards overburdening users and overtaxing their attention. There is a research gap with reference to this area of overtaxing individuals within the environment of use rather than laboratory settings (Graber, 1988).

2.5 Prior Research into Human-Agent Interaction

Work has been completed that created agents for the purpose of communicating with human by mimicking human voice patterns, body language, and emotions (Bruce et al, 2002). The drawback to this particular system was that it was completed through a computer simulation that made the human user conceptually move into the virtual environment for the interaction to take place. Such a system is not available with an agent in a real environment, yet. There are robotic agent systems available that communicate with human users, but given the highly specialized method by which these robotic agents are created and tested they can only communicate with their developers and programmers. This is a significant obstacle for the layperson or Soldier to immediately communicate with an agent in a multimodal, highly stressful environment such as a combat engagement.

Another realm of prior research is developing agents to respond to human speech and body language, specifically in the case of Kismet at MIT (MIT, 2006). Kismet is another example of a system where the robotic agent and developer are essentially training one another in communications. Kismet is unable to effectively communicate with a random adult human pulled of the street from somewhere in Cambridge, Massachusetts. The focus of this thesis is the effectiveness of communications from agent to human, with the prior research and areas of development the focus is on the agent receiving inputs from the human, not the human receiving the input from the agent.

As a result of the theoretical review several guidelines for the development of an experiment into a meta-language framework for human-agent communications have arisen:

visual, auditory, and haptic input modalities are all acceptable mediums for communications; based on the Card et al, 1983 and Stanney et al, 2004 model of human processor and work done on multimodal processing, if using a haptic source for communications the messages should excite the bodies rapidly adapting mechanoreceptors for most rapid reactions, combinations of input modalities may be an effective means for communications; communications should be prioritized to enable those messages most important in the "foreground" and unimportant status type messages remain in the "background" as to not overwhelm the user; messages, regardless of medium, should excite a user experimental cognition; and finally, the communications should be tailored to the users and environment for which its meant to be used in.

2.6 Research Question and Hypothesis

Upon the review of the gathered guidelines the following research question has been developed to assess the importance of input modality and the effect that it may have upon response time and message effectiveness:

Is there a difference upon the test subject response time by input modality as well as the effectiveness of the message (effectiveness is correct interpretation and the reception of the message)?

The null hypothesis for the experiment is equality amongst the sample means, whereas the alternative hypothesis is that there is some difference between the sample means.

CHAPTER THREE: METHODOLOGY

The objective of this research was to determine the best means of communication from an agent to a human team member. Specifically the impact the communications type (visual, auditory, and haptic) has upon the performance of the human in terms of response to the agent communication and the correct interpretation of that communication. As stated previously, three separate and distinct communications signals were given to the test subject in an effort to time their reaction from the moment the signal is presented until the moment the test subjects reacted. The three communications signals are: 1. visual – a hand and arm signal consisting of an agent moving into the prone position to communicate enemy in sight; 2. auditory – a natural, low frequency sound of pack hunting animals, in this case hyena; and 3. haptic – a neoprene vest with encapsulated cell phone vibrators that apply a momentary (1-2 second) haptic cue to the test subject.

3.1 Research Approach

The research methodology explored the best means of agent to human communication using a PC based simulation software; Soldier Visualization Systems (SVS), developed by Advanced Interactive Systems (AIS). SVS is desktop PC simulation software that enables training through various natural and urban environments and training scenarios to meet the demands of any military or law enforcement organization (Advanced Interactive Systems, Inc., 2006). The SVS platform allows for the development of a custom scenario along with the capabilities to record the performance of the user during the course of the simulation. SVS allows for multiple users to simultaneously perform in a virtual environment (Figure 6) while being simultaneously supervised by a scenario controller whose screen allows for the controlling/manipulating of the scenario while in use (Figure 7). The custom scenario development capabilities of the Soldier Visualization System allowed for a scenario to meet the needs of this experiment.

Figure 6: Soldier Visualization System Synthetic Natural Environment.

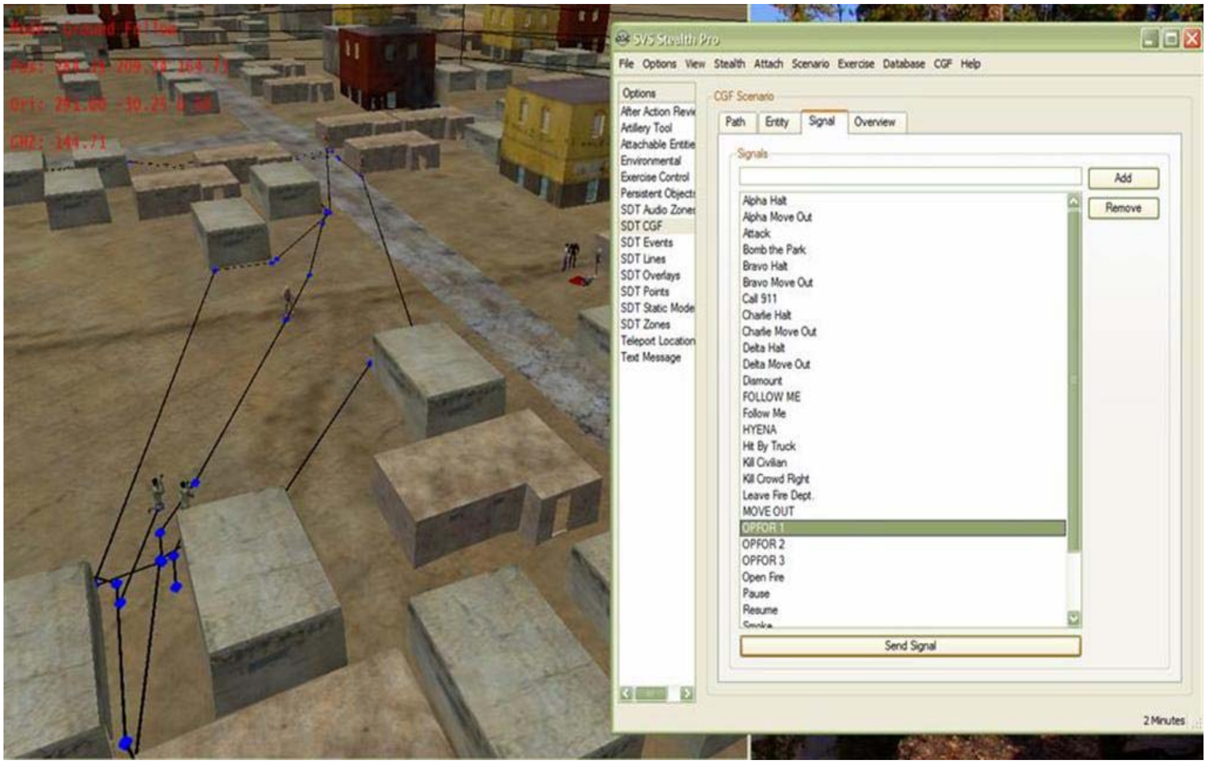

Figure 7: Soldier Visualization System Controller Panel.

The research methodology was not concerned with the transfer of training from simulation to real world application, but rather the effectiveness of agent to human communications through a variety of communication channels (visual, auditory and haptic). In addition to the effectiveness of communication, the correct interpretation of the agent to human communications was a secondary priority. The effectiveness of emotional communication between agents and humans was scored as the correct interpretation of the message by the human team members.

The primary vehicle for which to facilitate agent to human communications was the conduct of a movement to contact mission. Criteria for an appropriate scenario was based on performance measures as outlined in United States Army Field Manual 7-8 (The Infantry Rifle

Platoon and Squad) and the associated Battle Drills; React to Contact and Break Contact also listed in Field Manual (FM) 7-8. By depicting a human-agent team with the agent in the *point man* position (leading position of a moving element) and human team members following allowed for direct communication from the agent to human team member(s).

3.2 Task

The movement to contact task as outlined in United States Army Field Manual 7-8 is an offensive technique to find and fix the enemy for a variety of purposes that include but are not limited to: destruction of enemy forces, bypassing of enemy forces, and/or engaging the enemy with the smallest element possible (FM 7-8, Department of the Army, 1992). For a greater familiarity with military terminology, the United States Army doctrine defines fix or fixing as *a tactical mission task where a commander prevents the enemy from moving any part of his force from a specific location for a specific period of time* (FM 1-02, Department of the Army, 2004). Simply stated an enemy force is fixed when their ability to maneuver has been neutralized by direct or indirect fire for a period of time.

The movement to contact is a fundamental infantry task whose sole gain is determining the enemy location and fixing the enemy in place. Commanders conducting a movement to contact attempt to gain enemy contact with the smallest friendly force possible allowing for maximum flexibility in the maneuver of friendly forces to develop the engagement. This is done using a variety of methods to include different movement techniques and formations. Common to most movement formations is the use of a *point man* who is the lead soldier of the formation and whose responsibilities include: detecting enemy combatants, detecting obstacles, maintaining pace, and maintaining proper heading of the formation. In order to maintain the element of surprise prior to enemy contact, communications are covert and are typically limited to the use of hand and arm signals that are well known to each soldier in the formation and are a part of that units SOP (standing operating procedure).

The conduct of this task was suitable for experimentation purposes because it places the agent *point man* in a position to directly communicate with human team members and elicit an emotional response from the human team members. The elicited emotional responses may vary from caution to urgency and are dependent upon the method of communication from the agent team member and the interpretation of the test subject. As the element members are moving and providing over-watch for their particulars sectors they are also responsible for keeping visual contact with the *point man*.

It is important to note the focused nature of the task with respect to the conduct of the experiment. United States Army Infantry squads would be required to conduct additional battle drills along with a movement to contact. As stated above the movement to contact is an offensive engagement and as a result of any direct contact engagement there are a number of battle drills associated with direct contact such as: squad attack, react to contact, break contact, enter building/clear room, and casualty evacuation (FM 7-8, Department of the Army, 1992). The experiment was solely focused on the movement to contact and the performance of the resulting communications between agent *point man* and human fire team member. Although FM 7-8 clearly refers to the squad movement to contact this experiment used the smaller formation of a fire team as not overwhelm the test subject. Additionally, the experiment was not hampered by four less human agents (the second fire team that when added to the first and a leader makes a nine man US Army squad) in the scenario.

Beginning with the basic training of soldiers it is a routine mantra that if you can see the enemy, the enemy can see you and the same should be said that if you can hear the enemy, the enemy can hear you. Applied to the SVS experiment scenarios, using auditory cues are not practical yet they yield an appropriate starting point to measure the effectiveness of agent-human team communications. The ability to replicate hand and arm signals is in keeping with US Army practices, yet using an overt auditory cue to the detection of enemy is not practiced. This not only alerts the enemy to the presence of friendly forces but also give the enemy an area to focus their attention upon. The previously mentioned mantra does begin to lose its potency in units equipped with newer technology. For example with night vision systems and infrared (IR) signaling devices communications can continue to be covert even within the proximity of the enemy, unless the enemy is so equipped. Battlefield technology continues to advance as evident with the initial fielding of the US Army's Land Warrior system. Land Warrior is a wearable computer system that integrates weapon devices (designator, laser rangefinder) with a small screen, helmet mounted viewer that displays graphics (including friendly forces locations), thermal images, and night vision images. This digital capability further advances the ability of units to communicate covertly within the proximity of the enemy. Currently SVS cannot replicate the majority of US Army hand and arm signals and as a result the visual communication signal was specified to the test subject as the movement of the point man into the prone position pointing its weapon in the direction of the enemy. This was not strictly keeping with US Army practices as there are a variety of hand and arm signals alerting the remainder of the unit as to enemy detection and direction and my be used instead as dictated by the situation.

3.3 Subjects

Table 1: Test Subject Descriptive Statistics from Demographic Survey

	n	*M*	*Median*	*Mode*	*SD*
Gender (Male = 1)					
Female	6	0.87	1	1	0.34
Male	39				
Military Science Level					
1	13	2.38	2	3	1.39
2	10				
3	14				
4	8				
Military Experience					
0	27	1.42	0	0	2.31
1	7				
4	5				
5	3				
6	1				
8	2				
Age					
18	3	21.27	21	19	2.6
19	11				
20	5				
21	10				
22	7				
23	1				
24	3				
25	1				
27	2				
28	2				
Computer Familiarity					
1	1	2.87	3	3	0.59
2	7				
3	35				
4	1				
5	1				
Proclivity to Presence					
Scores Range 43 - 106	45	77.20	77	77	13.99

3.4 Materials

The device used in this experiment was a Dell Latitude D820, 2GHz processor, 2GB RAM, 80 GB Hard Drive, NVIDIA Quadro NVS 110M (256MB), 2.0 USB Ports, Firewire, Windows XP, and CD/DVD (CD/RW) (Figure 8). Interface with the system was based on user preference but kept to the use of the notebook keyboard or through the notebook keyboard in combination with a mouse. The choice of interface provided the capability for the subject to control their avatar in a means most comfortable to the test subject. This comfort-ability with the interface appeared to alleviate any concerns the subject had with avatar control and the effect that may have played on their performance.

Figure 8: Dell Latitude D820.

The laptop screen displayed a 2.5 dimensional synthetic natural environment that synchronized with an aural environment capable of aural localization (Advanced Interactive Systems, Inc., 2006). A second personal computing setup was also used to enable the specific scripting, commanding, and controlling of the exercise and it ensured a uniform scenario presentation to each subject regardless of which experimental group they may have belonged to.

3.5 Procedures

The experiment was conducted over a six day period in February 2007. The experiment with each test subject was conducted in three phases: Phase One began with the signed consent form and ended with an immersive tendencies questionnaire; Phase Two began with the immersive tendencies questionnaire completion and ended with Soldier Visualization System simulation familiarization; Phase Three began with Soldier Visualization System simulation familiarization completion and ended with the post-experimentation questionnaire completion.

Phase One of the test subject experimentation began with the consent form and ended with the immersive tendencies questionnaire. Test subjects were required to complete and sign an Informed Consent Form (Appendix A), complete a Demographic Survey (see Appendix B), and complete an Immersive Tendencies Questionnaire (developed by ARI, Appendix C) prior to participating in the experiment. The demographic survey was conducted to provide additional statistical insight into the subjects used for this experiment. The demographic survey was used mainly to provide insight into each test subject's computer familiarity for later use in regression analysis to determine whether computer familiarity affected reaction times within the experiment. The immersive tendencies questionnaire was used to measure the test subject's proclivity to presence (the subject experience of being in one environment (virtual) while being physically located in another environment (Singer, Witmer, and Goldberg, 1996). The immersive tendencies questionnaire was used to purely draw conclusions concerning a test subject's performance and their proclivity to immersion in simulation.

Phase Two of the subject experimentation began with the subject immersive tendencies questionnaire completion and ended with Soldier Visualization System simulation familiarization. Upon the completion of the immersive tendencies questionnaire, each test subject received a short briefing concerning the conduct of a movement to contact (visual search of sector of responsibility, visual contact with point man, actions upon contact, and a hand and arm signal demonstration by the proctor) and conducted a familiarization with both the simulation environment and the interface with the simulation environment for no longer than a ten minute period. The familiarization encompassed an overview of movement procedures, weapons firing, and avatar posture. This allowed for greater comfort-ability with simulation and enabled the test subject to understand the capabilities of the avatar, interface controls (weapon firing, weapon reloading, walking/running), and the visual/aural environment.

Phase Three began with the Soldier Visualization System simulation familiarization completion and ended with the post-experiment questionnaire (Appendix D). Upon the conclusion of the SVS familiarization, the experiment scenario was loaded up and started for the test subject. Depending upon the pace of the test subject the scenario lasted 3-5 minutes on average. At the conclusion of the experiment scenario response times and interpretation of agent communications were recorded, and the test subject was asked to complete the post-experiment questionnaire.

3.6 Experimental Design

The experiment was a one on one between the test subject and the proctor and began with the informed consent form and ended with the completion of the post-experiment questionnaire. Test subjects were presented each communication signal in a random order unbeknownst to the test subject prior to the start of the experiment. The randomness of the presentation of communication signals to each test subject was done in an effort to mitigate against the potential effect of learning by the test subject during the conduct of the experiment scenario. The visual communication signal (point man in the prone position pointing weapon in the direction of the enemy) numbered signal one was effectively the control communication signal and replicated current US Army practices as discussed earlier in this chapter. The auditory communication signal, numbered signal two, was a low frequency sound typical of pack hunting animals in the process of stalking prey, in this experiment the hyena provided the auditory communication signal. The haptic communication signal, numbered signal three, was provided by a neoprene vest with encapsulated cell phone vibrators (Figure 9 and Figure 10) and used Bluetooth® technology to communicate wirelessly with the controller station laptop.

Figure 9: Haptic Communication Device (View 1).

Figure 10: Haptic Communications Device (View 2).

In each instance the point man proceeded along a specific path within the synthetic natural environment (SVS's Baaditha, a non-specific Middle Eastern environment) during daylight hours with team members in trail conducting a movement to contact with enemy combatants. At the point prior to enemy contact the point man momentarily stopped, provided the appropriate communication cue (appropriate to order for the test subject), and then proceeded towards the enemy location. In reality the point man would not directly proceed to the enemy contact (unless the situation dictated it), but for the purpose of this experiment if the test subject continues along the avenue of approach without regard to the enemy then that was a clear indication of their failure to interpret the communication signal. The point man did not stop along its path only at the moment prior to contact as that may be a tip to the test subject of impending contact. The point man stopped at several waypoints along its avenue of approach, mainly to give the appearance of tactical movement (e.g. a stop prior to moving around a corner as if scanning for enemy up ahead).

Again, the use of overt communications (the auditory communication signal) in addition to the direct movement towards the enemy location are significant tactical mistakes, but they aided in the test subjects need to make a decision concerning their future movement and actions within the synthetic natural environment.

Each test subject was instructed to follow their *point man* in the conduct of a movement to contact operation in addition to maintaining situational awareness and an appropriate field of fire. Along the predetermined agent route opposing forces were poised to provide fire if the test subject enters their field of fire whether the test subject heeded the point man's communication or not. This was also a means to measure whether the agent's communications had an effect or was correctly interpreted by the test subject. For instance, a test subject that had moved without caution or concern towards the opposing force position indicated a failure in the reception or interpretation to the agent communication.

As stated earlier, each test subject was responsible for maintaining position, field of fire / field of view, and visual contact with the agent team member in the synthetic natural environment. In this instance there is an advantage of using ROTC Cadets rather than people from the general public. Participants from the general public would likely follow the point man regardless of the current situation or factors from the environment whereas ROTC Cadets have a greater familiarity of tactical movement. In military operations it is the responsibility of each unit member to continuously assess the environment and their future actions. Placed in context with tactical movement this means that it's not blindly following the leader and walking into the same ambush as those in front of you but rather taking the appropriate actions to accomplish the mission, protect yourself and unit, whilst following orders and the commander's intent.

Each test subject was scored by two criteria: did they correctly interpret the agent communication and how long did it take to react after the agent team member communicated the detection of enemy contact. The interpretation of agent team member communication was a go or no-go score while reaction times from test subjects will be averaged within the communication signal group and compared to the other two communication signal test groups using ANOVA.

One proctor was used to administer each of the experiments and adhere to the scripted protocol. The proctor is a United States Army Major, 31 years of age with 11 years of military service. The proctor's military experience includes duty in the United States as well as the Republic of South Korea, Kosovo, and Iraq. During the 11 year period of military service the proctor's experience includes 12 months as a platoon leader of 34 soldiers and 21 months as a Battery Commander directly responsible for the training, preparedness, and welfare of 84 Artillerymen. The proctor's experience as a Battery Commander included the deployment and direct combat operations of the Battery during Operation Iraqi Freedom.

CHAPTER FOUR: DATA ANALYSIS

As described in Chapter Three, the experiment was conducted over a six day period with 45 Cadets from the University of Central Florida US Army Reserve Officer Training Corps. Table 1 is reprinted in this chapter and explained to provide descriptive statistical insight into the makeup of the experiment participants. Data on participants and their performance were recorded after the execution of the experiment for each individual and completed before the execution of the experiment for the next individual. This allowed for the managing of samples to ensure at a minimum thirty samples were recorded for each communication signal to allow for assumption of sample normality and the use of the z statistical tables for normal curve areas. It is important to note concerning the assumption that the sample population is normally distributed; it is rarely known whether a sampled population has an exact normal distribution. Empirical studies have been conducted and indicate that moderate departures from the assumption of normality do not seriously affect the confidence coefficients (Mendenhall & Sincich, 1995). A confidence interval of 95.0% and $\alpha = 0.05$ were used throughout the calculations of statistical information.

4.1 Analysis of Demographic Surveys

Following the methodology of the experiment, each test subject was asked to answer a demographic survey whose main goal was to provide insight into a test subject's computer familiarity and is based off of a scale from one to five. A score of one is a user considered to be a novice with basic computer familiarity while a score of five is a user who is capable of programming in multiple computer languages. A complete analysis of the test subject demographics is displayed in Table 1.

Description of statistic for each group beginning with gender, it is clearly noticeable the test subjects were predominately male at 86.6%. This is not either uncommon for Army ROTC Departments nor the United States Army as the total active duty force is 85.7% male (Army G-1, 2005). The mean military science level for the test group was 2.38 indicating the test subjects were mostly between their MS 2 and MS 3 years, while the mode for military science level was MS 3. The overwhelming majority of test subjects had no prior military background; there were 18 cadets with some military experience with the mode being up to one year. The mean age for the test subjects is 21.27 and this closely corresponds with the mean military science level of the test subjects. A cadet who attends college immediately after graduating high school and joins the ROTC program would be a MS 3 at the age of 21. The last two demographic parameters are computer familiarity and proclivity to presence. The average computer familiarity score of three indicates that the majority of test subjects are familiar with multiple software packages but are unable to program in any computer languages. The maximum score for immersive tendencies questionnaire is a 126, the mean for this grouping of test subjects is 77.20. The mean proclivity to presence score for this test group of 77.20 with a standard deviation of 13.99 closely tracks the results of the immersive tendencies questionnaire; Army Research Institute developers used a n=132, with a mean of 76.66 and a standard deviation of 13.61 (Singer et al, 1996).

Table 1: Test Subject Descriptive Statistics from Demographic Survey					
	n	*M*	*Median*	*Mode*	*SD*
Gender (Male = 1)					
Female	6	0.87	1	1	0.34
Male	39				
Military Science Level					
1	13	2.38	2	3	1.39
2	10				
3	14				
4	8				
Military Experience					
0	27	1.42	0	0	2.31
1	7				
4	5				
5	3				
6	1				
8	2				
Age					
18	3	21.27	21	19	2.6
19	11				
20	5				
21	10				
22	7				
23	1				
24	3				
25	1				
27	2				
28	2				
Computer Familiarity					
1	1	2.87	3	3	0.59
2	7				
3	35				
4	1				
5	1				
Proclivity to Presence					
Scores Range 43 - 106	45	77.20	77	77	13.99

4.2 Analysis of Performance Scores

As previously stated in Chapter Three, each test subject was exposed to three communications signals in random order as to mitigate for the effect of learning. Upon review of each test subjects AAR (After Action Review) each subject was scored, using the simulation time clock, from the moment a communication signal was presented until there was a reaction made by the test subject. Test subjects failing to respond to any or all communication signals were given a maximum score of 10.00 seconds. Table 2 depicts the results for the 45 test subjects along with the mean and standard deviation for each communication signal and the percentage of successful reactions indicating the effectiveness of that communication. The percent of successful reactions is the total numbers of reactions observed for each communication signal compared to the total number of test subjects. Note, next to the participant number is the order in which the communication signals were presented (in parenthesis) to each test subject.

Table 2: Test Subject Performance Data			
PARTICIPANT	**VISUAL (1)**	**AUDITORY (2)**	**HAPTIC (3)**
1 (123)	2.01	10.00	2.89
2 (132)	2.20	4.25	2.03
3 (213)	1.64	10.00	2.40
4 (231)	10.00	10.00	10.00
5 (312)	1.27	10.00	0.88
6 (321)	2.52	10.00	10.00
7 (123)	1.93	10.00	10.00
8 (132)	0.41	2.67	1.59
9 (213)	4.59	2.72	2.05
10 (231)	10.00	2.66	2.85
11 (312)	10.00	3.92	2.93
12 (321)	10.00	2.11	10.00
13 (123)	10.00	2.19	2.64
14 (132)	2.44	3.14	1.20
15 (213)	10.00	10.00	1.12
16 (231)	2.06	4.18	0.92
17 (312)	2.50	2.43	2.03
18 (321)	2.47	10.00	1.92
19 (123)	10.00	2.99	2.43
20 (132)	10.00	3.67	1.67
21 (213)	1.47	3.78	1.96
22 (231)	1.26	3.92	1.17
23 (312)	10.00	3.30	0.47
24 (321)	10.00	1.96	2.01
25 (123)	2.16	10.00	3.54
26 (132)	10.00	2.14	1.87
27 (213)	4.18	10.00	3.46
28 (231)	1.67	2.37	2.18
29 (312)	6.14	10.00	1.47
30 (321)	0.97	2.04	3.46
31 (123)	2.38	10.00	3.23
32 (132)	2.82	3.41	2.18
33 (213)	4.74	3.52	1.62
34 (231)	1.39	1.92	2.87
35 (312)	1.51	2.27	2.34
36 (321)	3.64	3.91	3.31
37 (123)	2.09	3.90	1.81
38 (132)	1.18	10.00	1.05
39 (213)	3.07	10.00	1.78
40 (231)	2.43	10.00	2.17
41 (312)	1.71	4.80	2.42
42 (321)	1.85	2.58	1.38
43 (123)	2.45	3.18	1.19
44 (132)	2.20	2.96	2.80
45 (213)	1.76	3.58	1.84
MEAN	**4.20**	**5.39**	**2.78**
STD DEV	**3.49**	**3.36**	**2.40**
% EFF	**75.56%**	**66.67%**	**91.11%**

Fort-five test subjects allowed for seven full iterations (e.g. presentation of scenario's 123, 132, 213, 231, 312, and 321) and one partial iteration of only the first three simulation scenarios.

Maximum scores of 10.00 seconds have been removed from Table 3 and correctly indicate the final mean and standard deviation for each communication signal, the percent effectiveness has not changed. Tables 4, 5, and 6 illustrate the mean, standard deviation, and 95.0% confidence interval for each sample. All calculations were performed in Minitab® 15 Statistical Software.

Table 3: Test Subject Performance Data without Maximum Scores.		
VISUAL (1)	**AUDITORY (2)**	**HAPTIC (3)**
2.01	4.25	2.89
2.20	2.67	2.03
1.64	2.72	2.40
1.27	2.66	0.88
2.52	3.92	1.59
1.93	2.11	2.05
0.41	2.19	2.85
4.59	3.14	2.93
2.44	4.18	2.64
2.06	2.43	1.20
2.50	2.99	1.12
2.47	3.67	0.92
1.47	3.78	2.03
1.26	3.92	1.92
2.16	3.30	2.43
4.18	1.96	1.67
1.67	2.14	1.96
6.14	2.37	1.17
0.97	2.04	0.47
2.38	3.41	2.01
2.82	3.52	3.54
4.74	1.92	1.87
1.39	2.27	3.46
1.51	3.91	2.18
3.64	3.90	1.47
2.09	4.80	3.46
1.18	2.58	3.23
3.07	3.18	2.18
2.43	2.96	1.62
1.71	3.58	2.87
1.85		2.34
2.45		3.31
2.20		1.81
1.76		1.05
		1.78
		2.17
		2.42
		1.38
		1.19
		2.80
		1.84
2.327	**3.082**	**2.076**
1.17	**0.796**	**0.778**

Table 4: Z Test and Confidence Interval for Visual Communications Signal			
ONE SAMPLE Z TEST AND CONFIDENCE INTERVAL			
The standard Deviation = 1.17			
N	Mean	SE Mean	95.0% CI
34	2.327	0.201	(1.934, 2.720)

Table 5: Z Test and Confidence Interval for Auditory Communications Signal			
ONE SAMPLE Z TEST AND CONFIDENCE INTERVAL			
The standard Deviation = 0.796			
N	Mean	SE Mean	95.0% CI
30	3.082	0.145	(2.797, 3.367)

Table 6: Z Test and Confidence Interval for Haptic Communications Signal			
ONE SAMPLE Z TEST AND CONFIDENCE INTERVAL			
The standard Deviation = 0.778			
N	Mean	SE Mean	95.0% CI
41	2.076	0.122	(1.838, 2.314)

SE Mean is the standard error and measure how precisely the sample mean measures the population mean and it also allows for the estimate of the confidence interval for the population. A lower SE Mean indicates a more precise estimation of the actual population mean. By comparing the values in Tables 4,5, and 6 the SE Mean indicates that the sample mean for the haptic communication signal more precisely estimates the mean of reaction time for the entire population of Soldiers using a haptic communications messaging system. According to the calculated Confidence Interval, 95% of the population would react between 1.9 seconds and 2.7 seconds to a visual communications signal, between 2.8 seconds and 3.4 seconds to a auditory communication signal, and finally between 1.8 seconds and 2.3 seconds to a haptic communication signal.

4.3 ANOVA Analysis of Performance Scores

The null hypothesis for the ANOVA (Analysis of Variances) for the three sample group is that $\mu 1 = \mu 2 = \mu 3$, while the alternative hypothesis is that $\mu 1 \neq \mu 2 \neq \mu 3$. Table 7 describes the values determined by performing one-way ANOVA and comparing each sample mean to each other sample mean. Figure 11 graphically displays the differences in means and the confidence intervals for each sample.

Table 7: One-way ANOVA for Visual, Auditory, and Haptic

ONE-WAY ANOVA: VISUAL, AUDITORY, HAPTIC					
Source	DF	SS	MS	F	P
Factor	2	15.495	7.747	8.18	0.001
Error	87	82.376	0.947		
Total	89	97.871			
S = 0.9731		R-Sq = 15.83%		R-Sq(adj) = 13.90%	

```
Individual 95% Confidence Intervals For Mean Based on Pooled
                   Standard Deviations

Level  N   Mean    StDev    ----+---------+---------+---------+-----
VIS    34  2.3268  1.1705       (------*-----)
AUD    30  3.0823  0.7963                      (------*-----)
HAP    41  2.0763  0.7777    (-----*----)
                            ----+---------+---------+---------+-----
                               2.00      2.50      3.00      3.50

Pooled StDev = 0.9277
```

Figure 11: Individual 95% CI's for Mean Based on Pooled Standard Deviation.

The one-way ANOVA test of the three samples (Table 7) is statistically significant due to the calculated p-value of 0.001. With a confidence interval of 95.0% the $\alpha = 0.05$, as a result the p-value < α, and therefore the null hypothesis cannot be accepted, and ultimately the alternative hypothesis, $\mu1 \neq \mu2 \neq \mu3$, cannot be rejected. The input for this ANOVA test was the values from Table 3 and do not include max scores.

A second ANOVA test of the three samples (Table 8, Figure 12) was performed maintaining max scores within the samples. This second ANOVA is also statistically significant due to the calculated p-value of 0.001. With a confidence interval of 95.0% the $\alpha = 0.05$, as a result the p-value < α, and therefore the null hypothesis cannot be accepted, and ultimately the alternative hypothesis, $\mu1 \neq \mu2 \neq \mu3$, cannot be rejected.

Table 8: One-way ANOVA for Visual, Auditory, and Haptic Incorporating Max Scores.

ONE-WAY ANOVA: VISUAL, AUDITORY, HAPTIC w/ MAX SCORES					
Source	DF	SS	MS	F	P
Factor	2	153.4	76.7	7.88	0.001
Error	132	1284.49	9.73		
Total	134	1437.9			
S = 3.119		R-Sq = 10.67%		R-Sq(adj) = 9.32%	

Individual 95% Confidence Intervals For Mean Based on Pooled Standard Deviations

```
Level   N   Mean    StDev   ----+---------+---------+---------+-----
VIS     45  4.202   3.486             (-------*-------)
AUD     45  5.388   3.361                      (-------*-------)
HAP     45  2.781   2.398     (------*-------)
                            ----+---------+---------+---------+-----
                                2.4       3.6       4.8       6.0

Pooled StDev = 3.119
```

Figure 12: Individual 95% CI's for Mean Based on Pooled Standard Deviation Incorporating Max Scores.

The final results of the experiment do not support the null hypothesis that the mean of each sample are equal and therefore the null hypothesis cannot be accepted. The reaction time of each test subject to the various communication cues provided different and distinct means and standard deviations. Given that the null hypothesis is rejected, that the sample means are equal, the alternative hypothesis, the samples means are unequal, can be accepted. Having different and distinct sample means and standard deviations are not the true indicators to reject the null hypothesis but do provide insight into which form of communications provides for a faster response time as well as a indicator to the effectiveness of communications in terms of correct interpretations and communication reception rate. Although the resultant p-value provides a statistically significant result does not infer that the result is of practical significance, or indicates a large effect in the overall US Army population (Gelman & Stern, 2006).

Given the large F-statistic for each of the ANOVA tests, a second analysis of the data was conducted to using Tukey Post Hoc analysis. The results of each communication signal (both with and without 10.00 second max scores) were pair-wise analyzed against one another and are depicted in Tables 9 and 10.

Table 9: Tukey Post Hoc Analysis (No Max Scores)			
Scenario	Calculated Value	Tukey Critical Value	Significance
Audio vs. Haptic	5.662	3.49	Yes
Visual vs. Haptic	1.410	3.49	No

Table 10: Tukey Post Hoc Analysis (w/ Max Scores)			
Scenario	Calculated Value	Tukey Critical Value	Significance
Audio vs. Haptic	5.606	3.42	Yes
Visual vs. Haptic	3.055	3.42	No

Given the final results from the Tukey Post Hoc Analysis there does not appear to be a significant improvement of haptic communication signals compared to the visual communications with using max scores and no max scores. Yet in both instances there appears to be a significant improvement of using haptic communication signals when compared to audio communication signals.

A Chi-Squared (Chi^2) was conducted for observations concerning receipt of communication signals. Table 11 depicts the Chi^2 values for those who received the communication signals and those who did not for each type of communication signal used in the experiment. The null hypothesis for this calculation is again that each communication signal is equal to the other two communication signals.

Table 11: Chi^2 Values for Message Receipt by Communications Type

Chi2 Values for Message Receipt by Communications Type					
		VISUAL	**AUDIO**	**HAPTIC**	
					TOTAL
REC'D MESSAGE	Observed Count	34.00	30.00	41.00	105.00
	Expected Count	35.00	35.00	35.00	
	$\chi 2$ Contribution	0.029	0.714	1.029	
DID NOT REC'D MESSAGE	Observed Count	11.00	15.00	4.00	30.00
	Expected Count	10.00	10.00	10.00	
	$\chi 2$ Contribution	0.100	2.500	3.600	
TOTAL		45	45	45	135
Chi-Sq = 7.971, DF = 2, P-Value = 0.019					

Using Mendenhall et al, page 1101, Critical Values of Chi^2 for $\alpha = 0.05$, with two degrees of freedom, the critical value of Chi^2 is 5.999147. The calculated value of Chi^2 is 7.971 and now the null hypothesis can be rejected and affirm the claim that the different communications signals have different affects upon the test subjects.

A second Chi^2 was conducted to determine if there is a relationship between the theoretical limit of receiving the communication signal (every test subject) and the observed values of those who received the communication signal, table 12 depicts the Chi^2 the results. The null hypothesis being each communication signal has an equal probability of being received by the test subject. The Chi^2 was conducted to determine a relationship between the communication signal delivered and the expectation of it being received by the test subject.

Table 12: Chi² Values for Communication Received				
			Actual	**Theoretical Max**
Visual	Received Signal	Observed	34.00	45.00
		Expected	39.50	39.50
	Did Not Receive Signal	Observed	11.00	0.00
		Expected	5.50	5.50
Chi-Sq = 12.532, DF = 1, P-Value = 0.000				
			Actual	**Theoretical Max**
Audio	Received Signal	Observed	30.00	45.00
		Expected	37.50	37.50
	Did Not Receive Signal	Observed	15.00	0.00
		Expected	7.50	7.50
Chi-Sq = 18.000, DF = 1, P-Value = 0.000				
			Actual	**Theoretical Max**
Haptic	Received Signal	Observed	41.00	45.00
		Expected	43.00	43.00
	Did Not Receive Signal	Observed	4.00	0.00
		Expected	2.00	2.00
Chi-Sq = 4.186, DF = 1, P-Value = 0.041				

In each instance the Chi^2 value exceeded the critical value (degrees of freedom = 1,α of 0.05, critical value = 3.84146) and the null hypothesis cannot be accepted for each communication signal. There appears to be no statistical relationship between communication signal and the expectation that it will be received.

4.4 Regression Analysis of Mitigating Factors in Overall Performance

The demographic survey was given prior to the execution of the experiment with the main purpose to provide insight into the computer familiarity of each test subject. Since the main vehicle for the experiment was a PC simulation through a computer regression was used to investigate and mitigate computer use as a factor in overall performance. The immersive tendencies questionnaire is another factor used to mitigate overall performance, and was used similar to computer familiarity as a independent variable for regression. There were wide variations within the responses to each communication cue but it did not appear to be a result of the test subject's computer familiarity or proclivity to presence as depicted by Tables 13, 14, 15 and Figures 13, 14, and 15. In each case of regression (with independent variables demographic survey score or immersive tendencies score, or both) the coefficient of determination is less than 1.5% indicating that the independent variable is a strong predictor of the subjects overall score yet in each case the normal probability plot demonstrates positive linear correlation.

Table 13: Regression Analysis for DEM and ITQ Scores.

Regression Analysis: OVR SCORE versus DEM, ITQ				
The regression equation is OVR SCORE = 16.6 - 0.37 DEM - 0.0409 ITQ				
Predictor	Coef	SE Coef	T	P
Constant	16.591	5.836	2.84	0.007
DEM	-0.371	1.508	-0.25	0.807
ITQ	-0.0409	0.06332	-0.65	0.522
S = 5.73517 R-Sq = 1.4% R-Sq(adj) = 0.0%				

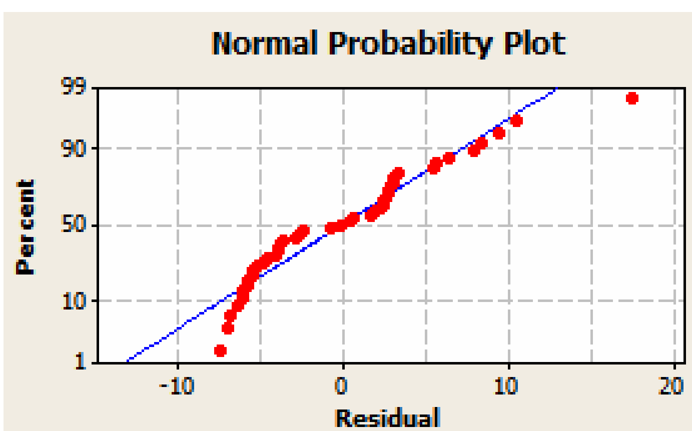

Figure 13: Normal Probability Plot for DEM and ITQ Scores.

Table 14: Regression Analysis for DEM.Scores.				
Regression Analysis: OVR SCORE versus DEM				
The regression equation is OVR SCORE = 14.0 - 0.58 DEM				
Predictor	Coef	SE Coef	T	P
Constant	14.045	4.274	3.29	0.002
DEM	-0.584	1.461	-0.4	0.692
S = 5.69618 R-Sq = 0.4% R-Sq(adj) = 0.0%				

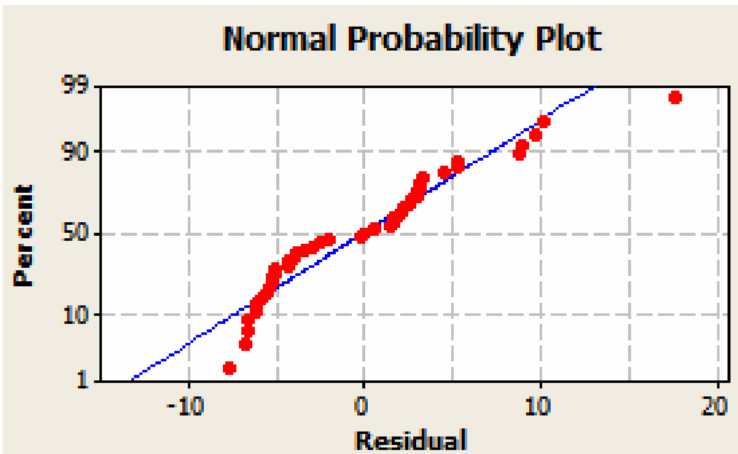

Figure 14: Normal Probability Plot for DEM Scores.

Table 15: Regression Analysis for ITQ Scores.				
Regression Analysis: OVR SCORE versus ITQ				
The regression equation is OVR SCORE = 15.8 - 0.0443 ITQ				
Predictor	Coef	SE Coef	T	P
Constant	15.792	4.792	3.3	0.002
ITQ	-0.04431	0.0611	-0.73	0.472
S = 5.67216 R-Sq = 1.2% R-Sq(adj) = 0.0%				

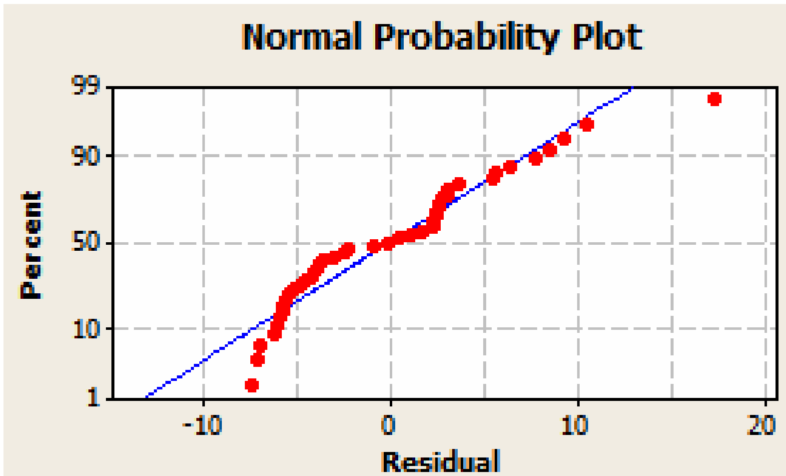

Figure 15: Normal Probability Plot for ITQ Scores.

4.5 Test Subject Communication Preference versus Actual Performance

Table 16 indicates the variations in test subject preferred means of communications (e.g. visual, auditory, or haptic) but notably these preferences did not always pair up with the performance data, or in other words the test subject didn't do as well to the communication cue they preferred but instead to a different communication cue. A Chi^2 test was conducted to determine a statistical significance between test subject preference and the test subject performance. The null hypothesis is that the observed frequency of preference for each communication signal is equal. The test subject preferences were taken from the post-experiment questionnaire. One last item of significance to note is the dominated preference to the visual form of communications. Table 17 depicts the result of the Chi^2 test for test subject preference to the communication signals.

Table 16: Test Subject Communication Preference versus Actual Performance				
PARTICIPANT #	**VISUAL (1)**	**AUDITORY (2)**	**HAPTIC (3)**	**SUBJECT PREF**
1 (123)	2.01	10.00	2.89	VISUAL
2 (132)	2.20	4.25	**2.03**	**VISUAL**
3 (213)	1.64	10.00	2.40	VISUAL
4 (231)	10.00	10.00	10.00	VISUAL
5 (312)	1.27	10.00	0.88	HAPTIC
6 (321)	**2.52**	10.00	10.00	**AUDIO**
7 (123)	1.93	10.00	10.00	VISUAL
8 (132)	**0.41**	2.67	1.59	**HAPTIC**
9 (213)	4.59	2.72	2.05	HAPTIC
10 (231)	10.00	**2.66**	2.85	**HAPTIC**
11 (312)	10.00	3.92	**2.93**	**VISUAL**
12 (321)	10.00	**2.11**	10.00	**HAPTIC**
13 (123)	10.00	2.19	2.64	**AUDIO**
14 (132)	2.44	3.14	**1.20**	**AUDIO**
15 (213)	10.00	10.00	1.12	HAPTIC
16 (231)	2.06	4.18	0.92	HAPTIC
17 (312)	2.50	2.43	**2.03**	**AUDIO**
18 (321)	2.47	10.00	1.92	HAPTIC
19 (123)	10.00	2.99	**2.43**	**VISUAL**
20 (132)	10.00	3.67	**1.67**	**AUDIO**
21 (213)	1.47	3.78	1.96	VISUAL
22 (231)	1.26	3.92	**1.17**	**VISUAL**
23 (312)	10.00	3.30	**0.47**	**VISUAL**
24 (321)	10.00	**1.96**	2.01	**HAPTIC**
25 (123)	2.16	10.00	3.54	VISUAL
26 (132)	10.00	2.14	**1.87**	**AUDIO**
27 (213)	4.18	10.00	**3.46**	**AUDIO**
28 (231)	**1.67**	2.37	2.18	**HAPTIC**
29 (312)	6.14	10.00	1.47	HAPTIC
30 (321)	**0.97**	2.04	3.46	**HAPTIC**
31 (123)	2.38	10.00	3.23	VISUAL
32 (132)	2.82	3.41	**2.18**	**VISUAL**
33 (213)	4.74	3.52	1.62	HAPTIC
34 (231)	1.39	1.92	2.87	VISUAL
35 (312)	1.51	2.27	2.34	VISUAL
36 (321)	3.64	3.91	**3.31**	**VISUAL**
37 (123)	2.09	3.90	**1.81**	**VISUAL**
38 (132)	1.18	10.00	1.05	**VISUAL**
39 (213)	3.07	10.00	1.78	HAPTIC
40 (231)	2.43	10.00	**2.17**	**VISUAL**
41 (312)	**1.71**	4.80	2.42	**AUDIO**
42 (321)	1.85	2.58	1.38	HAPTIC
43 (123)	2.45	3.18	1.19	HAPTIC
44 (132)	2.20	2.96	2.80	VISUAL
45 (213)	1.76	3.58	1.84	VISUAL

Table 17: Chi^2 Values for Test Subject Message Preference by Communications Type

Chi2 Values for Test Subject Message Preference by Communications Type					
		VISUAL	**AUDIO**	**HAPTIC**	
					TOTAL
OBSERVED MESSAGE PREFERENCES	Observed Count	21.00	8.00	16.00	45.00
	Expected Count	18.00	11.50	15.50	
	χ2 Contribution	0.500	1.065	0.016	
EXPECTED MESSAGE PREFERENCES	Observed Count	15.00	15.00	15.00	45.00
	Expected Count	18.00	11.50	15.50	
	χ2 Contribution	0.500	1.065	0.016	
Chi-Sq = 3.163, DF = 2, P-Value = 0.206					

Although the visual communications signal was preferred by 46.67% of the test subjects, compared to 35.56% who preferred the haptic communications signal and 17.78% who preferred the auditory communications signal, the Chi^2 test depicts no statistical significance. Using Mendenhall et al, page 1101, Critical Values of Chi^2 for $\alpha = 0.05$, with two degrees of freedom, the critical value of Chi^2 is 5.999147. The calculated value of Chi^2 is 3.163 and now the null hypothesis cannot be rejected and affirm the claim that the different communications signals have equal preference amongst the test subjects.

It is important to reiterate though from Table 2, the haptic communications signal was 91.11% effective in eliciting a response versus 75.56% for the visual communications signal. Given that there appears to be no statistical significance for communication signal preference coupled with the faster response time to haptic communications and the greater response to the haptic communications it appears that haptic forms of communications are a viable means of human-human and human-agent communications.

CHAPTER FIVE: CONCLUSIONS, LIMITATIONS, LESSONS LEARNED AND AREAS OF FUTURE RESEARCH

Haptic communications have the potential to be just a versatile as visual communications. An excellent example is the cell phone vibrator; separate pulses communicate to the user different signals such as incoming call, incoming text message or voicemail, and even low battery. Haptic communications potentially have the same or greater depth to messages that are available with visual or auditory communications, but the argument can be made concerning the learning curve to familiarize individuals with this new form of communications. What needs to be kept in mind is the target audience, the American Soldier. The American Soldier is capable of rapidly adapting to any change and will train until a high state of readiness is achieved. A benefit of haptic communications versus visual and auditory is how it may fit in a combat environment. Soldiers within the team to do not have to be in a position to see the robotic agent nor do they have to be within range to hear a signal from the agent. Covertness of communications is maintained regardless of environment, time of day, or type of operation. This provides a complication for those attempting to intercept communications between team members and units in an effort to disrupt friendly unit operations. Additionally, through the available research presented in Chapter 2 it is very evident that humans cannot only handle multimodal interactions but excel and prefer those types of interactions.

5.1 Discussion

This research study was done in order to gain insight into an effective means of communications for future interactions between robotic agents and human team members. Additionally, information gleamed from this study could be applied to protocols currently used by the United States Army to either augment or replace current communications practices. From ANOVA comparisons of the scores for each communication signal the null hypothesis was not accepted and therefore a basis of comparison for each mean is possible. As a result the mean for the haptic communication signal was 0.25 seconds faster than the visual communication signal. The 95.0% confidence interval (an interval that 95.0% of the population should score within) for the haptic communication signal was 0.10 seconds faster on the low end and 0.42 seconds faster on the high end. This may not appear to be exceptionally significant but in the life and death situations of combat any advantage over the enemy should be used and exploited to maximize friendly forces operational effectiveness. Additionally there was a large portion of the sample that did not even receive the signal for the visual and auditory communications. Defined as Percentage of Effectiveness, visual communications were 75.56% effective, auditory communications were 66.67% effective, while haptic was 91.11% percent effective. The effectiveness of the signal combined with the faster reaction time indicates that the haptic communications signal is the best of the three signals.

It also appears that the experiment was able to effectively capture true test subject reaction times un-hampered by their computer familiarity. The regression data shows that computer familiarity and the test subject's proclivity to presence had no effect upon their overall score. If not previously stated earlier, the overall score is simply the summation of the reaction times to each communication signal.

The demographic surveys provided additional insights into another observed behavior of the test subject's. The majority of test subject's preferred the visual communication signals over the remaining two communication signals. Table 1 depicts the average military science level at 2.38 which places a cadet in between the military science 2 and military science 3 levels. During this time the Cadets are learning hand and arm signals along with small unit Infantry tactics in preparation for ROTC Advanced Camp. Advanced Camp is an eight week long course located at an active US Army installation that places each Cadet through a rigorous training and evaluation regimen to score and rank each Cadet against their peers. Ultimately this ranking provides the US Army a basis of comparison for Cadets and their preferences for component (Active, Reserve, National Guard), branch (Infantry, Armor, Field Artillery, etc.), and duty assignment (Fort Bragg, Fort Hood, Fort Campbell, etc.). Ultimately it should be no surprise that the visual form of communications was the most preferred because it is what the Cadets are currently most familiar with and have the highest degree of familiarity with. In the post-experiment questionnaire the test subjects were asked as to their preferred form of communications and why, some reasons why visual was stated as their preference are:

- Easier for me
- Larger perception area with head on a swivel
- Because I saw it and knew when to react
- I feel like I can gain the most information through my eyes and that the simulation provides more information through visual signals than any other

- I react that the most when I see it

The haptic communication signal was the second most preferred but was the most unfamiliar to each test subject prior to the start of the experiment. There were some excellent reasons as to why it was preferred upon the conclusion of the experiment and those include:

- Felt it, not necessary to look at the point man
- It engages more of the body and so gives an increased urgency to the receipt of the message
- Cause it doesn’t matter where your looking & not distracted by noise
- Alerts body senses immediately, regardless of other sights/sounds

The comments concerning the haptic communications signal clearly demonstrate the effectiveness of the communication with regard to the other sights and sounds of the environment the test subjects were operating in.

5.2 Limitations of Research

Although the Soldier Visualization System enables the exercise controller to develop a scenario to train a specific task it does also have its limitations. The simulation does not have the capabilities or models to allow entities to mimic the full range of hand and arm signals in use by the United States Military. This limited the capabilities and realism of visual communications to be used by the point man. An alternative hand and arm signal for enemy in sight is a soldier either in the standing, kneeling, or prone position pointing in the direction of the enemy. This limited the range of visual communication cues that could be used and as a result limited a full range of multimodal communications.

The models within SVS also preclude the layman from developing detailed entity models for use in the simulation. It would require working knowledge of computer programming and 3D modeling to integrate new capabilities to existing models or to develop entirely new models for use within the simulation. Again as a result, a full range of visual communications (lights, poses, individual movements, etc.) was untapped and unused in this experiment.

Although there were enough Cadets to provide at least 30 samples of each communication signal and therefore assume normality of the distribution, it would have been beneficial to have more depth and a greater number of samples. It is probably standard for any research study to have wanted increased resources but in this situation a larger sample size may have been able to reduce the large standard deviation of the visual communication signal. Although it is entirely plausible that because a visual communication cue is only effective if it is seen that the standard deviation was larger than the other two communication cues. Such an ambiguity could only be answered with a larger sample size.

5.3 Lessons Learned

It may have been beneficial to vary the audio communications signal to incorporate additional low frequency pack-hunting animal sounds and/or man-made warning sounds. This would have given greater depth to the audio signal and provided a sound of greater familiarity that would allow more test subjects to respond. It is possible though by providing a sound with greater familiarity it may have skewed the results to the audio sound.

A second lesson learned is the need for dedicated test subjects. College students, even those in Army ROTC, have too many competing demands placed upon their time. As such their complete participation can not always be counted on. The UCF Army ROTC department did an excellent job of ensuring that all 45 promised cadets did show as they had promised. Having dedicated subjects whose participation can be guaranteed would be ideal.

Logistics is another lesson learned from the conduct of this thesis and especially after the conduct of the experiment. Ensuring all needed hardware and funds for the conduct of research is fully in place including any administrative tasks prior to the start of the experiment would greatly simplify the process. Not knowing on the first day of experimentation whether the test subjects would show because of an administrative hurdle can be stressful.

5.4 Areas for Future Research

Building upon the results of the experiment and taking it a step further there appear to be several areas of future research:

- Confounding the haptic input and re-evaluate the experiment.
- Evaluation of location for haptic communication reception.

- Development and testing of a system of communications that is multimodal (e.g. uses a combination of visual, auditory, and haptic signals).
- Development of a haptic communications language, one that encompasses the current library of hand and arm signals and the scenarios for which they are used.
- Evaluation of haptic communications against visual communications using active duty combat arms Soldiers.
- Incorporation of haptic messaging device into Land Warrior.
- Development of a human interface that will enable human team members to communicate with one another with minimal keystrokes while maintaining a minimum of one hand on a weapon.
- Communications security for wireless communications between team members.

Confounding the haptic input and re-evaluate the experiment: Test subjects had to look upon a computer screen and see a visual signal to react to along with listen to background audio and hear an audio signal. There was not a multiple point of input for the haptic modality, the vest provided the only input and it was activated at the time the signal was sent. Would the test subjects do as well if the haptic communications signals were sent during a hail storm?

Evaluation of location for haptic communication reception: During the conduct of the experiment the location of message reception was the torso. An evaluation can be conducted to determine if the torso or another portion of the body provides for an increase in reaction time to a communication signal.

Development and testing of a system of communications that is multimodal (e.g. uses a combination of visual, auditory, and haptic signals): It is clear based not only upon literature but through a objective view of daily human behavior that people process the world around them in multiple modalities. Based upon the concepts of redundant-signal processing would a communications systems based upon multimodal inputs truly aid in the speed of reaction, effectiveness, and interpretation of communication signals from agent to human team members.

Development of a haptic communications language, one that encompasses the current library of hand and arm signals and the scenarios for which they are used: During the course of the experiment included in this thesis there was only one message, ENEMY IN SIGHT, and it was delivered through a single pulse. To demonstrate the effectiveness and range of haptic communications a haptic language must be developed to meet the same messages currently delivered by hand and arm signals. There is room to expand the library of messages by modifying the duration or intensity of the vibration. For example, a single pulse may indication ENEMY IN SIGHT, but by modifying the intensity the message could be relayed as ENEMY IN SIGHT – CLOSE or ENEMY IN SIGHT – FAR. In addition to the various communication signals they must apply to the variety of missions and situations that Soldiers find themselves in. These missions vary from direct combat to humanitarian mission support.

Evaluation of haptic communications against visual communications using active duty combat arms Soldiers: Once a message library has been developed an evaluation of the system compared to current practices should be conducted to determine whether to continue research and resources to the project. If there are no advantages of haptic messaging compared to current hand and arm signals there should be no more resources applied to the research. Ideally using active duty combat arms Soldiers, whose daily lives are committed to small unit tactics and operations, would be best to evaluate such a system and input into improvement would be invaluable. From the evaluation point forward to implementation, then a wider base of all soldiers regardless of branch would benefit from the work done by the evaluating soldiers with the greater insight and experience.

Evaluation of haptic communications against visual communications using active duty combat arms Soldiers: Incorporating the haptic messaging system into current US Army projects or future projects would demonstrate the applicability and depth of such a communications device along with the versatility in its use.

Development of a human interface that will enable human team members to communicate with one another with minimal keystrokes while maintaining a minimum of one hand on a weapon: This should not need much explanation. The key is allowing the Soldier to communicate without removing his/her hands on weapon or having to place the weapon down. If a hand would have to be removed from the weapon it would ideally be the non-trigger finger hand.

Communications security for wireless communications between team members: The experiment used a Bluetooth® wireless interface for communications between the controller laptop and the haptic vest. There are a wide variety of communications security protocols but it is critical for the survival and effectiveness of Soldier's in the field that communications are not compromised.

APPENDIX A: CONSENT FORM

Informed Consent and Procedural Information

for participation in research study titled: IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK IN MILITARY APPLICATIONS

Please read this consent document carefully before you decide to participate in this study.

You must be 18 years of age or older to participate.

Project title: IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK IN MILITARY APPLICATIONS

Purpose of the research study: The goal of the research is to determine the best means of agent to human non-verbal emotional communication in a military setting.

What will you be asked to do in this study: You will be asked to control a human avatar in a synthetic natural environment and interpret the communication and take appropriate actions within the simulation.

Time required: Approximately 30 – 45 minutes total. You are free to terminate participation in this experiment at any time without bias.

Risks: There is no known risk of physical discomfort or exertion working on this desktop PC simulation.

Benefits/Compensation: Your participation will help the academic and military community better understand the best means for human – agent communication that will lead to greater human – agent teamwork in future operations.

Confidentiality: Your identity will be kept confidential to the extent provided by law. Your information will be assigned a code number. The list connecting your name to this number will be kept in a locked file in the principal investigators office. When the study is complete and the data has been analyzed, the list will be destroyed. Your name will not be used in any report.

Voluntary participation: Your participation in this research is voluntary. There is no penalty for not participating.

Right to withdraw from the study: You have the right to withdraw from the study at any time without consequence.

Points of contact for questions concerning the study: Major Gil Cardona, Department of Industrial Engineering, University of Central Florida, Orlando, Florida, 32816; phone 407/823-5296; email: gilbert.cardona@us.army.mil

Whom to contact about your rights in the study: Institutional Review Board (IRB), University of Central Florida (UCF), 12201 Research Parkway, Suite 501, Orlando, Florida 32826-3246, Telephone: (407) 823-2901

Consent Form and Voluntary Agreement
for participation in research study titled: IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK IN MILITARY APPLICATIONS

You must be 18 years of age or older to participate.

I, ____________________________________ (please print your full name), having full capacity to consent, do hereby volunteer to participate in research titled, **IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK IN MILITARY APPLICATIONS** under supervision of Dr. Michael Proctor. The implications of the nature, duration, and purpose of the research, and the method and means by which it is to be conducted are contained on the second page of this consent packet. I have been given an opportunity to read a copy of this agreement and to ask questions concerning this research. Any such questions have been answered in full and complete satisfaction. Should further questions arise, I will be able to contact MAJ Gil Cardona at (407) 926-4532 or gilbert.cardona@us.army.mil , or Professor Michael Proctor at (407) 823-5296 or mproctor@mail.ucf.edu . I understand that I may at any time during this research revoke my consent and withdraw from the test without prejudice, and I will maintain my compensation for my participation.

Note: If you believe you have been injured during participation in this research project, you may file a claim with UCF Environmental Health & Safety, Risk and Insurance Office, P.O. Box 163500, Orlando, FL 32816-3500 (407) 823-6300. The University of Central Florida is an agency of the State of Florida for purposes of sovereign immunity and the university's and the state's liability for personal injury or property damage is extremely limited under Florida law. Accordingly, the university's and the state's ability to compensate you for any personal injury or property damage suffered during this research project is very limited. Information regarding your rights as a research volunteer may be obtained from:

IRB Coordinator
Institutional Review Board (IRB)
University of Central Florida (UCF)
12201 Research Parkway, Suite 501
Orlando, Florida 32826-3246
Telephone: (407) 823-2901

____ ________________

Signature Date

APPENDIX B: DEMOGRAPHIC SURVEY

DEMOGRAPHIC QUESTIONNAIRE

Participant # ___

Date __________

1) Age _____
2) Gender M / F
3) Major _________________________
4) Highest level of education _________________________
5) When did you start using a computer in part of your education? ____________________
6) For each of the following questions please circle the best answer that describes you.

How often do you use a mouse?
Daily Weekly Monthly Never

How often do you use a joystick?
Daily Weekly Monthly Never

How often do you use play PC Video Games?
Daily Weekly Monthly Never

How often do you use software with icons and pull-down menus?
Daily Weekly Monthly Never

How often do you check email?
Daily Weekly Monthly Never

7) Which of the following best describes your computer experience?

   Novice

   Good with one type of software package (word processing, presentations)

   Good with multiple software packages

   Ability to program in one computer language

   Ability to program in more than one computer language
8) How many hours of sleep did you get last night? _____
9) Are you in your usual state of health? YES / NO
10) Do you have any prior military service? YES, how long _____ / NO

APPENDIX C: IMMERSIVE TENDENCIES QUESTIONNAIRE AND SCORING GUIDELINES

IMMERSIVE TENDENCIES QUESTIONNAIRE

(Witmer & Singer, Version 3.01, September 1996)

Indicate your preferred answer by marking an "X" in the appropriate box of the seven point scale. Please consider the entire scale when making your responses, as the intermediate levels may apply. For example, if your response is once or twice, the second box from the left should be marked. If your response is many times but not extremely often, then the sixth (or second box from the right) should be marked.

1. Do you easily become deeply involved in movies or tv dramas?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

2. Do you ever become so involved in a television program or book that people have problems getting your attention?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

3. How mentally alert do you feel at the present time?

|________|________|________|________|________|________|________|
NOT ALERT MODERATELY FULLY ALERT

4. Do you ever become so involved in a movie that you are not aware of things happening around you?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

5. How frequently do you find yourself closely identifying with the characters in a story line?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

6. Do you ever become so involved in a video game that it is as if you are inside the game rather than moving a joystick and watching the screen?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

7. What kind of books do you read most frequently? (CIRCLE ONE ITEM ONLY!)

Spy novels	Fantasies	Science fiction
Adventure novels	Romance novels	Historical novels
Westerns	Mysteries	Other fiction
Biographies	Autobiographies	Other non-fiction

8. How physically fit do you feel today?

|________|________|________|________|________|________|________|
NOT FIT MODERATELY FIT EXTREMELY FIT

9. How good are you at blocking out external distractions when you are involved in something?

|________|________|________|________|________|________|________|
NOT VERY GOOD SOMEWHAT GOOD VERY GOOD

10. When watching sports, do you ever become so involved in the game that you react as if you were one of the players?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

11. Do you ever become so involved in a daydream that you are not aware of things happening around you?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

12. Do you ever have dreams that are so real that you feel disoriented when you awake?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

13. When playing sports, do you become so involved in the game that you lose track of time?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

14. How well do you concentrate on enjoyable activities?

|________|________|________|________|________|________|________|

NOT AT ALL MODERATELY WELL VERY WELL

15. How often do you play arcade or video games? (OFTEN should be taken to mean every day or every two days, on average.)

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

16. Have you ever gotten excited during a chase or fight scene on TV or in the movies?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

17. Have you ever gotten scared by something happening on a TV show or in a movie?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

18. Have you ever remained apprehensive or fearful long after watching a scary movie?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

19. Do you ever become so involved in doing something that you lose all track of time?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

20. On average, how many books do you read for enjoyment in a month?

|________|________|________|________|________|________|________|

NONE ONE TWO THREE FOUR FIVE MORE

21. Do you ever get involved in projects or tasks, to the exclusion of other activities?

|________|________|________|________|________|________|________|

NEVER OCCASIONALLY OFTEN

22. How easily can you switch attention from the activity in which you are currently involved to a new and completely different activity?

|________|________|________|________|________|________|________|
NOT SO EASILY — FAIRLY EASILY — QUITE EASILY

23. How often do you try new restaurants or new foods when presented with the opportunity?

|________|________|________|________|________|________|________|
NEVER — OCCASIONALLY — FREQUENTLY

24. How frequently do you volunteer to serve on committees, planning groups, or other civic or social groups?

|________|________|________|________|________|________|________|
NEVER — SOMETIMES — FREQUENTLY

25. How often do you try new things or seek out new experiences?

|________|________|________|________|________|________|________|
NEVER — OCCASIONALLY — OFTEN

26. Given the opportunity, would you travel to a country with a different culture and a different language?

|________|________|________|________|________|________|________|
NEVER — MAYBE — ABSOLUTELY

27. Do you go on carnival rides or participate in other leisure activities (horse back riding, bungee jumping, snow skiing, water sports) for the excitement of thrills that they provide?

|________|________|________|________|________|________|________|
NEVER — OCCASIONALLY — OFTEN

28. How well do you concentrate on disagreeable tasks?

|________|________|________|________|________|________|________|
NOT AT ALL — MODERATELY WELL — VERY WELL

29. How often do you play games on computers?

|________|________|________|________|________|________|________|
NOT AT ALL — OCCASIONALLY — FREQUENTLY

30. How many different video, computer, or arcade games have you become reasonably good at playing?

|________|________|________|________|________|________|________|
NONE ONE TWO THREE FOUR FIVE SIX OR MORE

31. Have you ever felt completely caught up in an experience, aware of everything going on and completely open to all of it?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY FREQUENTLY

32. Have you ever felt completely focused on something, so wrapped up in that one activity that nothing could distract you?

|________|________|________|________|________|________|________|
NOT AT ALL OCCASIONALLY FREQUENTLY

33. How frequently do you get emotionally involved (angry, sad, or happy) in news stories that you see, read, or hear?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

34. Are you easily distracted when involved in an activity or working on a task?

|________|________|________|________|________|________|________|
NEVER OCCASIONALLY OFTEN

Scoring

In general, the questionnaires are easy to score. Simply score the boxes from left to right beginning with one and increasing in value to the box the subject has marked, and the number of that box becomes the score. Some of the questions have reversed response anchors, and are scored so the left-most box receives a seven and the rest decrease in value. The subscale scores are the sum of the scores for each subscale item. There is no weighting of items or subscales. The questionnaire totals and subscales are comprised as follows:

IMMERSIVE TENDENCIES QUESTIONNAIRE

Total: Items 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19.
ITQ-Focus: Items 1, 3, 8, 9, 13, 16, & 19.
ITQ-Involvement: Items 2, 4, 5, 11, 12, 17, & 18.
ITQ-Games: Items 6 & 15.

New questions have been added to each questionnaire, but should not be added to the totals or subscales as they are just beginning to be investigated. The new (unanalyzed) questions are scored the same as the other questions, which should be reversed to fit the overall presence concept. Finally, we have kept item 7 in the ITQ, which has nominal responses and is not included in any scale. That item is still under investigation.

A NOTE AND REQUEST FROM THE AUTHORS.

The questionnaire is still evolving and may be for some time. As mentioned in the introduction, the phenomena is composed of a number of factors that are in turn only partially understood (or fully understood and only partially measurable).

We anticipate continuing to work on improving the questionnaires, at least as long as it takes to create a valid, reliable, and useful measure. In order for us to continue improving the questionnaire, we are asking that you share the data collected only for the purpose of analyzing the questionnaires validity, reliability, and usefulness! Sharing data will increase the size of the information pool and decrease the time necessary for development and testing. All of which will mean that if you want a good measure of presence, you don't have to work at developing one yourself. We would also appreciate constructive comments on the current batch of questions.

This cooperative request leaves us with the question of how to acknowledge contributions of data. So, if you want to share data, feel free to suggest ways in which we can attribute or acknowledge your intellectual (and/or experimental) contribution. If you have an opinion on how to apportion or share credit but don't have data to contribute, we would welcome short comments.

Necessary communication can be facilitated by using internet. Please contact us for discussion by sending email to:

Mike Singer - singerm@stricom.army.mil
Bob Witmer - witmerb@stricom.army.mil

APPENDIX D: POST-EXPERIMENT QUESTIONNAIRE

POST-EXPERIMENT QUESTIONNAIRE

Participant # ___

Date ___________

1) Did you acknowledge/understand the hand and arm signal form of communication?

2) Did you understand the intent of the communication?

3) Did you acknowledge/understand the auditory signal form of communication?

4) Did you understand the intent of the communication?

5) Did you acknowledge/understand the haptic signal form of communication?

6) Did you understand the intent of the communication?

7) Which form of communication did you feel was most effective (audio, visual, haptic)?

8) Why?

   ____

   ____

9) Do you have any input to improve the means and clarity of any form of communication experienced today?

   ____

   ____

   ____

APPENDIX E: EXPERIMENT DATA

PARTICIPANT #	SEX	MS LVL	MIL EXP	AGE	DEM	ITQ	VISUAL (1)	AUDITORY (2)	HAPTIC (3)	SUBJECT PREF	TOTAL TIME
1 (123)	F	1	0	27	2	72	2.01	10.00	2.89	VISUAL	14.90
2 (132)	F	2	0	23	3	76	2.20	4.25	2.03	VISUAL	8.48
3 (213)	M	3	1	21	3	50	1.64	10.00	2.40	VISUAL	14.04
4 (231)	M	3	0	21	3	73	10.00	10.00	10.00	VISUAL	30.00
5 (312)	M	1	4	24	3	64	1.27	10.00	0.88	HAPTIC	12.15
6 (321)	M	4	0	21	3	60	2.52	10.00	10.00	AUDIO	22.52
7 (123)	F	2	0	19	2	56	1.93	10.00	10.00	VISUAL	21.93
8 (132)	**M**	**3**	**0**	**20**	**3**	**85**	**0.41**	**2.67**	**1.59**	**HAPTIC**	**4.67**
9 (213)	M	2	0	21	3	79	4.59	2.72	2.05	HAPTIC	9.36
10 (231)	M	2	0	21	3	75	10.00	2.66	2.85	HAPTIC	15.51
11 (312)	M	3	1	21	3	101	10.00	3.92	2.93	VISUAL	16.85
12 (321)	M	3	0	21	3	96	10.00	2.11	10.00	HAPTIC	22.11
13 (123)	M	4	4	22	3	86	10.00	2.19	2.64	AUDIO	14.83
14 (132)	**M**	**4**	**0**	**22**	**3**	**43**	**2.44**	**3.14**	**1.20**	**AUDIO**	**6.78**
15 (213)	M	3	1	22	3	56	10.00	10.00	1.12	HAPTIC	21.12
16 (231)	F	3	5	22	3	87	2.06	4.18	0.92	HAPTIC	7.16
17 (312)	M	1	0	19	3	77	2.50	2.43	2.03	AUDIO	6.96
18 (321)	M	3	0	20	3	83	2.47	10.00	1.92	HAPTIC	14.39
19 (123)	M	4	0	22	3	77	10.00	2.99	2.43	VISUAL	15.42
20 (132)	M	3	5	22	3	70	10.00	3.67	1.67	AUDIO	15.34
21 (213)	M	3	0	21	3	69	1.47	3.78	1.96	VISUAL	7.21
22 (231)	**M**	**3**	**1**	**21**	**2**	**77**	**1.26**	**3.92**	**1.17**	**VISUAL**	**6.35**
23 (312)	M	1	1	19	3	106	10.00	3.30	0.47	VISUAL	13.77
24 (321)	M	2	0	20	3	79	10.00	1.96	2.01	HAPTIC	13.97
25 (123)	M	4	6	28	3	57	2.16	10.00	3.54	VISUAL	15.70
26 (132)	M	1	0	18	1	65	10.00	2.14	1.87	AUDIO	14.01
27 (213)	F	3	4	24	3	85	4.18	10.00	3.46	AUDIO	17.64
28 (231)	M	3	5	24	3	87	1.67	2.37	2.18	HAPTIC	6.22
29 (312)	M	1	0	19	3	104	6.14	10.00	1.47	HAPTIC	17.61
30 (321)	M	2	4	22	3	79	0.97	2.04	3.46	HAPTIC	6.47

31 (123)	M	2	0	19	2	88	2.38	10.00	3.23	VISUAL	15.61
32 (132)	M	2	1	19	3	74	2.82	3.41	2.18	VISUAL	8.41
33 (213)	M	4	8	27	3	78	4.74	3.52	1.62	HAPTIC	9.88
34 (231)	**M**	**1**	**1**	**19**	**3**	**61**	**1.39**	**1.92**	**2.87**	**VISUAL**	**6.18**
35 (312)	M	2	0	19	2	90	1.51	2.27	2.34	VISUAL	6.12
36 (321)	F	1	0	18	2	61	3.64	3.91	3.31	VISUAL	10.86
37 (123)	M	1	0	19	2	85	2.09	3.90	1.81	VISUAL	7.80
38 (132)	M	1	0	19	3	77	1.18	10.00	1.05	VISUAL	12.23
39 (213)	M	1	0	20	4	77	3.07	10.00	1.78	HAPTIC	14.85
40 (231)	M	2	0	20	3	81	2.43	10.00	2.17	VISUAL	14.60
41 (312)	M	1	0	19	3	72	1.71	4.80	2.42	AUDIO	8.93
42 (321)	**M**	**3**	**0**	**21**	**3**	**87**	**1.85**	**2.58**	**1.38**	**HAPTIC**	**5.81**
43 (123)	**M**	**1**	**0**	**18**	**5**	**99**	**2.45**	**3.18**	**1.19**	**HAPTIC**	**6.82**
44 (132)	M	4	4	25	3	92	2.20	2.96	2.80	VISUAL	7.96
45 (213)	M	4	8	28	3	78	1.76	3.58	1.84	VISUAL	7.18
MEAN		**2.38**	**1.42**	**21.27**	**2.87**	**77.20**	**4.20**	**5.39**	**2.78**		**12.37**
STANDARD DEVIATION		**1.09**	**2.31**	**2.60**	**0.59**	**13.99**	**3.49**	**3.36**	**2.40**		**5.64**
MODE	**M**	**3**	**0**	**19**	**3**	**77**				**VISUAL**	
% EFFECTIVENESS							**75.56%**	**66.67%**	**91.11%**		
MEDIAN		**2**	**0**	**21**	**3**	**77**					

APPENDIX F: IRB SUBMISSION AND APPROVAL LETTER

B. UCF IRB Protocol Submission Checklist

All Institutional Review Board (IRB) information can be obtained via the Internet or from the IRB Coordinator and Assistants at the Office of Research. Please submit to the following address:

Address:
Office of Research (Attn: IRB Coordinator)
12201 Research Parkway - Suite 501
Orlando, FL 2-3346
or Campus mail 32816+0150

Contact:
Phones: 407-882-2276, 407-823-2901
Fax: 407-823-3299
E-mail: IRB@mail.ucf.edu

The UCF IRB website address is: http://www.research.ucf.edu/compliance/irb.html

There is no deadline for minimal risk studies as they are reviewed by a Chairman or designated, experienced IRB member at least weekly. Allow a minimum of 2-3 weeks for the approval process. The completed IRB packet must be submitted by the 1st business day of the month for consideration at the monthly IRB meeting if the IRB determines that it is greater than minimal risk or that there are extenuating circumstances.

✓_____ UCF IRB Protocol Submission Form

✓_____ Consent form, letter or consent information sheet [unless study does not use human participants]

NA___ Child assent form [if participants are between 7-17 years of age]

NA___ School districts' research approval forms and school principals' permission letters [if applicable]

NA___ Statement that college class instructors' have approved if being announced or done in class

✓_____ Surveys, pre & post tests, questionnaires, interview questions, etc. [if applicable]

NA___ Copies of flyers and/or advertisements plus radio and/or television sample scripts, etc. [if applicable]

✓_____ Detailed research methodology [at least one page minimum]

NA ___ Physical or medical contingency plan [if applicable, for example available counseling]

✓_____ All investigators', supervisor's (if student) & department chair's signatures

✓_____ Current mailing address [especially students]: Gil Cardona
1804 Palmetto Pine Lane
Orlando, FL 32826

Principal Investigator: ________________________________ Date ________________

C. UCF IRB Protocol Submission Form

UCF IRB Protocol Submission Form

☐ Initial ☐ Revision of IRB #________ ☐ Resubmission of **expired** IRB #________

Please type this form using the Microsoft Word document. Expand as needed. Allow a minimum of 2-3 weeks for the approval process. A letter of approval will be mailed to you once approved. Information on this form must match information on the grant application, dissertation or thesis, consent forms or letters, and flyers for recruitment. **There are no deadlines for submission of minimal risk studies as they are reviewed at least weekly.** If it is deemed by the IRB that the study involves greater than minimal risk or extenuating factors, the complete IRB packet must be submitted by the 1st business day of the month for consideration at that monthly IRB meeting.

1. Title of Protocol: Thesis – **"IDENTIFICATION AND SUITABILITY OF A NON-ANTHROPOMORPHIC META-LANGUAGE FRAMEWORK FOR USE IN MILITARY APPLICATIONS.**"

2. Principal Investigator: [List the faculty supervisor as both the Principal Investigator and the faculty supervisor if undergraduate student(s) or staff members are doing the research. List student(s) as co-investigator(s). Doctoral and Masters candidates may list themselves as the Principal Investigator but their faculty supervisor must also be listed.]

Signature:
Name: Gilbert M. Cardona (PID # g1775985) College: Engineering and Computer Science
Major (choose one) E-Mail: gilbert.cardona@us.army.mil
Degree: BA Telephone: 407 926-4532
Title: Principal Investigator Facsimile: 407 926-4532
Department: Interactive Simulation (IEMS) Home Telephone: 407 926-4532

3. Supervisor: (complete if researcher is a student or staff member – contact information is above)

Signature:
Name: Michael D. Proctor College: Engineering and Computer Science
Dr. (choose one) E-Mail: mproctor@mail.ucf.edu
Degree: Ph.D. Telephone: 407 823-5296
Title: Associate Professor and Committee Chair Facsimile: 407 823-3413
Department: IEMS Engineering Building 2, Room 301-D

4. Collaborating institution(s) and researcher(s) (identify the institution and its FWA number, if known. List the names of collaborating researchers and briefly describe their roles in the study. Provide contact information. If the collaborating institution does not have a federal wide assurance, a completed UCF Individual Investigator Agreement is required prior to approval.) None.

5. Proposed dates of project (cannot be retroactive) From: January 27, 2007 To: May 31, 2007

6. Source of funding for the project (project title, agency, account/proposal # or “Unfunded”): Investigator tuition-sponsored.

7. Scientific purpose of the investigation (dissertation or thesis is not the scientific purpose)**:**

The primary research goal for this thesis is to identify and evaluate the suitability of a non-anthropomorphic meta-language framework consisting of pose, motion, haptics and non-speech sounds that may be used to communicate an emotional response that can be correctly interpreted by various entities, both human and non-human. Non-anthropomorphic robots, due to there lower cost and suitability, are already common in Iraq and other counties for numerous military tasks. As hand and arm signals, whistles, and even bugles have been used to communicate meaning and stir emotions in soldiers in the past, non-anthropomorphic robots may be equipped to supplement existing communications channels through pose, motion, color, and non-speech sounds. This would provide not only needed redundancy but extend communication channels into human perceived visual and auditory spectrum.

8. Describe the research methodology in non-technical language (the UCF IRB needs to know what will be done with or to the research participants – include audio/video taping – explain the who, what, when, where, why, and how of the procedures you wish to implement).

The experiment will be conducted over a two month period from January 2007 until February 2007. Each subject test will be conducted in three phases; Phase One begins with subject demographic survey and ends with subject immersive tendency questionnaire, Phase Two begins with subject immersive tendency questionnaire completion and ends with Soldier Visualization System familiarization, Phase Three begins with Soldier Visualization System familiarization completion and ends with experimentation scenario completion. The Soldier Visualization System (SVS) is desktop PC simulation software that enables training through various natural and urban environments and training scenarios to meet the demands of any military or law enforcement organization (Advanced Interactive Systems, Inc., 2006). The SVS platform allows for the development of a custom scenario along with the capabilities to record the performance of the user during the course of the simulation. SVS allows for multiple users to simultaneously perform in a virtual environment while simultaneously supervised by a scenario controller whose screen allows for the controlling/manipulating of the scenario while in use. The custom scenario development capabilities of the Soldier Visualization System allows for a scenario to meet the needs of this experiment.

Phase One of the subject experimentation begins with the demographic survey and ends with the subject immersive tendency questionnaire. Test subjects will be required to complete a Demographic Survey (see Appendix A), sign an Informed Consent Form (see Appendix B), and complete an Immersive Tendencies Questionnaire (developed by Army Research Institute, see Appendix C) prior to participating in the experiment. The demographic survey is conducted to provide additional statistical insight into the subjects used for this experiment as to their level of computer use and familiarity. The immersive tendencies questionnaire is used to measure the test subject’s proclivity to presence (the subjective experience of being in one environment (virtual) while being physically located in another environment (Singer et al, 1996). The immersive tendencies questionnaire is used to purely draw conclusions concerning a test subject’s performance and their proclivity to aspects of immersion in simulation.

Phase Two of the subject experimentation begins with the subject immersive tendency questionnaire completion and ends with Soldier Visualization System familiarization. Upon the completion of the immersive tendencies questionnaire a short briefing concerning the conduct of a movement to contact (visual search of sector of responsibility, visual contact with point man, actions upon contact, and a hand

and arm signal demonstration by the proctor), followed by a 10 minute familiarization with both the simulation environment and the interface with the simulation environment. The familiarization encompasses an overview of movement procedures, weapons firing, and avatar posture. This allows for greater comfort-ability with simulation and enables the test subject to understand the capabilities of the avatar, interface controls (weapon firing, jumping, walking/running), and the visual/aural environment.

Phase Three begins with Soldier Visualization System familiarization completion and ends with experimentation scenario completion. Upon the conclusion of the SVS familiarization, the experimental scenario is loaded up and started for the test subject. The test subject will be randomly assigned order for conducting four scenarios: a control scenario (using pose as a means of communication), an auditory scenario (using an auditory signal as a means of communication), a visual scenario (using a visual signal as a means of communication), and a haptic scenario (a vest sewn with cell phone encapsulated vibrators will be worn by the test subject and provides the communication cue). Depending upon the pace of the test subject each scenario will last 3-5 minutes. At the conclusion of the experimentation scenario response times and interpretation of agent communications (whether or not the proper interpretation on the part of the test subject was made) are recorded. Upon the conclusion of the simulation scenarios feedback from participants will be recorded as to the feedback from the agents, clarity of communication, and effectiveness of the communications in a post-experimentation questionnaire (Appendix D).

9. Describe the potential benefits and anticipated risks and the steps that will be taken to minimize risks and protect participants (risks include physical, psychological, social or economic harm - if there are no direct benefits and/or no risks, state that).

The direct benefit to the participants is the insight acquired by recording their reaction times and using their averages for comparison between each scenario group. Developers have focused on the means of communications from human to agent, but the data taken from this experiment will give direct insight into the means of communications from agent to human. The only direct risk to participants is the security of the information for each participant (consent form, demographic survey, and immersive tendencies questionnaire). Names of participants will be separate from experimental results so that results cannot be directly tied to participants Participant data will be maintained in a locked box until the completion of the thesis and then destroyed. The raw data will not appear in the thesis or any published results.
Data in paper form will be transferred to a spreadsheet that contains the results of the two instruments and the demographic data for each participant, but will not contain any information that would allow any participant to be identified.

10. Describe how participants will be recruited, how many you hope to recruit, the age of participants, and proposed compensation (if any). When recruiting college students, you should state here that "Participants will be 18 years of age or older" if you want to avoid the need for a parental consent form.

The 45 participants will be cadets taken from the UCF Army ROTC department. As an Active Duty Major I have worked an agreement with the ROTC department for the use of their cadets' time. The cadets will be 18 years of age or older.

11. Describe the informed consent process (include a copy of the informed consent document – if a waiver of documentation of consent is requested to make the study completely anonymous, include a consent form or informational letter with no signature lines or reference to signing).

See attached informed consent form (Appendix B).

12. Describe any protected health information (PHI) you plan to obtain from a HIPAA-covered medical facility or UCF designated HIPAA component (include the completed UCF HIPAA Authorization Form or the UCF HIPAA Waiver of Authorization Form giving the details of the planned use or disclosure of the PHI. See the UCF IRB Web page for HIPAA details and forms)**.** No health information will be collected in the conduct of this research.

I approve this protocol for submission to the UCF IRB. Signature: **_____________________/______**

Michael Proctor, Ph.D. Date

Associate Professor, IEMS

Cooperating Department (if more than one Dept. involved) Signature:

__N/A____________/______

Department Chair/Director

Date

University of Central Florida

Office of Research & Commercialization

January 25, 2007

Gilbert M. Cardona
1804 Palmetto Pine Lane
Orlando, FL 32826

Dear Mr. Cardona:

With reference to your protocol #07-4118 entitled, "Identification and Suitability of a Non-Anthropomorphic Meta-Language Framework for Use in Military Applications," I am enclosing for your records the approved, expedited document of the UCFIRB Form you had submitted to our office. **This study was approved on 01/24/2007. The expiration date for this study will be 01/23/2008.** Should there be a need to extend this study, a Continuing Review form must be submitted to the IRB Office for review by the Chairman or full IRB at least one month prior to the expiration date. This is the responsibility of the investigator.

Please be advised that this approval is given for one year. Should there be any addendums or administrative changes to the already approved protocol, they must also be submitted to the Board through use of the Addendum/Modification Request form. Changes should not be initiated until written IRB approval is received. Adverse events should be reported to the IRB as they occur.

Should you have any questions, please do not hesitate to call me at 407-823-2901.

Please accept our best wishes for the success of your endeavors.

Cordially,

Joanne Muratori

Joanne Muratori
(FWA00000351 Exp. 5/13/07, IRB00001138)

Copies: IRB File
Michael Proctor, Ph.D.

JM:jt

12201 Research Parkway • Suite 501 • Orlando, FL 32826-3246 • 407-823-3778 • Fax 407-823-3299

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