THE EFFECTS OF VARIATIONS IN INTER-MODAL HUMAN-COMPUTER INTERFACE DESIGNS ON
ACCURACY, TIMELINESS, AND SITUATIONAL AWARENESS OF USERS

A Dissertation in
Information Sciences and Technology

by

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ABSTRACT

The domain of emergency response command and control requires accurate and up-to-date models in order to support resource assignment decision-making. Furthermore, the division of responsibilities in some emergency operations centers requires that the models of the environment must be built within a technology-based data system simultaneously as situational awareness is sought by the various human users of the system. The combination of these efforts can become especially trying at times where messages arrive at an increased pace – which coincide with times where quality decision-making becomes more crucial. This investigation evaluates the utility of three inter-modal user interface variants for supporting the interpretation of audio messages and for sustaining situational awareness. Human-subject experimental results indicate that subtle changes in user interface composition can have significant impacts on the performances of users in respects to their interpretation speed, accuracy, and situational awareness. This research is inspired by the operations of emergency response command and control centers as environmental complexity increases through atypical levels. The term “inter-modal” refers to the receipt of messages describing changes in the environment in an audio format, which must be interpreted and refined by users in order to be entered into a digital database via a traditional computer keyboard-video-mouse interface.
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PREFACE

Large-scale geographically distributed emergency events are, thankfully, not common occurrences. There are, however, several examples within the past few decades which provide anecdotal evidence of the practical problems such events entail.


More information available at:
http://query.nytimes.com/gst/fullpage.html?res=9E0CE4D71039F932A35752C1A964958260&sec=&spon=&pagewanted=print
http://www.icjia.state.il.us/public/index.cfm?metasection=publications&metapage=STACNEWS_05_S95

In April 1992, the not-guilty verdicts of Los Angeles police officers accused of beating an African-American citizen precipitated several riots throughout the city.

More information available at:
http://www.fragmentsweb.org/stuff/photoking.html
http://www.emergency.com/la-riots.htm
In July 2005, a series of bombings affecting three subway stations and a bus took place in London.

Flooding in the U.S. mid-Atlantic region in June 2006 caused wide-spread damage and several deaths.

More information available at:
In each of the examples above, emergency response services, and their accompanying command and control organizations were strained beyond normal operating conditions. Emergency Communications personnel have reported that their workload maximizes in conditions where the needs for emergency resources are geographically distributed, yet linked within a larger event. (Jones, 2004) It is important to recognize that the individual incidents to which resources will be sent may be fairly straightforward and even simplistic; it is the number and distribution of the incidents that pose coordination issues to the command and control practitioners.
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My committee members: Mike, Dave, Fred, and Rob have made this a fulfilling, even if not a completely enjoyable, effort. I am thankful that you guys stuck with me for the ride.

Several other faculty and staff members, classmates, and students have acted as sources of inspiration and catalysts for clarity as I worked through my studies and I am grateful for your assistance, even if you were not aware you were giving it.

To the fine people who work tirelessly to make sure that when someone needs help the call is answered, I wish to thank you for your service and for allowing me to re-join your ranks for a time while I completed on this project.

To the students who participated in my experiment and allowed me to complete this work I wish great success with your continued studies and life beyond.

My wife, Maureen, and our children, Connelly and Grace, have been truly wonderful through the process of completing this work. I love you and hope to prove that all of those evenings and weekend afternoons I spent in study were worth it.
INTRODUCTION

Overview

The goal of this research is to explore aspects of ecologic human-computer interface design for domains where data is received primarily via voice communications. Much of the civilian emergency management command and control infrastructure is included within this model. Therefore, a secondary goal of this work is to provide a basis upon which improved decision support systems for emergency management operations can be designed.

The domain of emergency response command and control serves as the inspiration and as a back-drop for this work. In the United States alone, there are approximately 650,000 requests for emergency assistance each day in the United States. (NENA, 2009) Such requests are routed to one or more emergency operations centers (EOC’s) where information is processed and used to allocate emergency response resources to handle the situation. (NENA, 2009) As the police, fire, and/or medical personnel proceed through the processes of responding to the incident to which they have been assigned, they provide the EOC with feedback notifications of their progress. It is the combination of these incoming progress reports, and the continuing arrival of new requests for assistance which produces the cognitively challenging work environment upon which this investigation is focused.

Potential Benefits

As technology evolves and becomes increasingly able to support decision makers in various fields, it is necessary to re-evaluate the status quo to determine if and how new
technologic developments can be employed to produce better overall outcomes. While technology may provide opportunities for improved decision making, it has also made possible as well as for degraded decision making via increasingly overwhelming input data via cell-phone reports and increasingly ubiquitous networked sensors, and biased and bogus reporting and rumors. For the specific field of emergency response, a better outcome is very simply a reduction in the number of deaths, injuries, and property damage.

The desire to evaluate novel approaches to this or any similar domain should not be assumed to have the replacement of human actors with technologic agents as the desired outcome.

**General Model of this Investigation’s Target Domain**

In each of the incidents described in the preface, as in most distributed emergency conditions, the requirements for emergency response coordination were increased dramatically from the normal day-to-day levels. An important note on this statement is that while the required coordination effort within the emergency operations centers is increased, the local decision-making processes at any single incident is not greatly affected. The field practitioners of emergency response are able to focus their efforts on straightforward problems common to their specializations because they focus on each incident in a linear fashion, handling each incident on a case-by-case basis. For example: during a heavy wind and rain storm, causing wide-spread flooding and downed trees, the 911 operations center of a rural area of Pennsylvania was overwhelmed by the number of individual requests for assistance.(Jones,
2004) Reports of problems, some serious, some not so serious, were arriving faster than the emergency communications personnel could handle them. While the emergency operations center’s staff struggled to catalog and sort requests, allocate resources, and track the growing number of incidents, the police officers, firefighters, and emergency medical personnel working in the field were not overly stressed. In effect, the field responders were protected by the EOC staff from the complexity of the overall effort of which they were one part. The field resources were busy, to be sure: as soon as they reported the completion of one task, they were given another assignment requiring their immediate response. The field responders of each of the services were able to proceed from one situation to the next, according to the assignments given by the EOC. The true stress-point in the system was within the EOC, where a large volume of data needed to be continually collected, analyzed, and acted upon as quickly as possible.

In large scale distributed emergency situations, the difficulties in proper resource allocation are greatly amplified. The difficulty grows not only due to the number of identified needs and the number of individual resources being used, but also due to the increase in variations of the types of needs and resources. In normal day-to-day operations, the limited over-allocation of resources to individual incidents is acceptable, and in many cases is beneficial to the final disposition of the case. However, as the complexity of emergency situations increases, the constraints on resource allocation become much stricter and in many cases may overwhelm the normally used protocols.
In the realm of emergency medical services (EMS), a critical incident is manifested as a “mass casualty incident” or MCI. The definition of a mass casualty incident describes any situation where the number and severity of victims overwhelms the capabilities of a standard response, forcing the triage of care. (Branas et al., 2000)(Burkle, 2002) Triage of multiple victims, though a required component of all EMS training programs, is not part of the normal day-to-day activities of most EMS responders. The implementation of triage protocols in EMS response forces the responders out of their usual modality of individual patient treatment and imposes a new set of rules upon their actions. This new work paradigm expands beyond the basic hands-on activities the EMS personnel are expected to perform, and includes the formation of, and integration with, a new and sometimes dynamic command structure for the duration of the incident. This ad-hoc command structure should not be perceived as disorganization, but rather a reorganization of the EMS personnel at the scene of the incident. Specific roles are pre-defined and allocated among the individuals on hand. This reorganization into a local command structure alleviates the emergency operations centers’ personnel of a great deal of decision-making. Efficient decisions in such incidents require more information than can be accessed by the EOC’s with the currently implemented technology.

**Challenges**

The challenges of investigating the domain of emergency response command and control are many and complex. First, because emergency management is an integral element of the critical infrastructure of modern society there are security considerations related to the
observation and documentation of operational parameters beyond the level of very general functional descriptions. In many cases, observation and/or interviews with subject matter experts have been the primary source of information. Alternate methodologies, such as analysis of video or even audio-only recordings, were disallowed for security reasons. Such restrictions are not without precedent, and because of the additional privacy dictates have particularly affected research in emergency medical treatment environments. (Xiao & "The LOTAS Group", 2001)(Xiao et al., 1996)

Second, along with methodological restrictions and a fast pace of activity which cannot tolerate disruption for academic clarification, the use of domain-specific jargon has been cited as a hindrance to some emergency medicine research (Xiao et al., 1996). The environment of emergency services dispatch centers has a similar reliance on domain specific language. The use of proper names such as locations and police/fire/ambulance departments, which may be specific to a particular center’s territory, may cause confusion to an unfamiliar observer.

Third, investigation of such operations is challenging to a researcher because incidents are not repeatable in an experimental sense. Each incident, while belonging to a limited category of events or activities, is a “one of a kind” incident whose details cannot be replicated from one incident to another. Hence, study of decision-making in these centers must deal with how to address the fact that each incident and response is potentially unique.
MOTIVATION

Overview

The field of emergency resource command and control is constituted by a set of interrelated activities, agencies, protocols, and principles. The specific element of interest in this investigation is the ability of emergency operations centers to react to atypically complex situations. As most (but not all) EOC’s utilize some amount of computer-based information management technologies, a natural point upon which to focus some attention is the interactions of the EOC personnel and the digital information systems with which they work.

General Problem Description

Command and control systems rely upon accurate and timely models of the environment. When these systems involve the use of digital technologies, the models must be converted into a format suitable for use by the technologies. In situations such as those typically found in emergency operations centers (EOC’s), it is not possible for the technology to handle the incoming data describing the environment, therefore requiring a human component for basic data capture. (Hutchins, 1996)(von Ahn, 2007) This is the result of the fact that the incoming data arrives primarily in voice messages, either via telephone or radio. (Jones, 2004)(Jones & McNeese, 2006) Voice as the solitary means of information receipt differentiates the EOC domain from other command and control facilities such as those operated by the military or the air traffic control system. In those, and many other command and control work domains, data are compiled from a variety of sources and in a variety of
formats, many of which are more readily usable for automated information derivation. (Hall & Llinas, 1997)

Humans perform far better than computers for tasks such as visual pattern recognition, and other tasks that require the rapid analysis of seemingly disparate pieces of data (von Ahn, 2007), but often fall short on the recall of details. The book “On Intelligence” (Hawkins & Blakeslee, 2004) and subsequent publications from Hawkins’ software company, Numenta, make a strong case that humans use a “memory-prediction framework” and act primarily as “prediction engines” rather than as computational platforms. This framework accounts for humans’ propensity toward hierarchical organization of concepts, and the subsequent loss of detail.

The requirement of having people as part of an information system introduces variation into the quality and rate of data processing. As the frequency and complexity of cognitive tasks increases, so does the opportunity for greater variation. These variations, when occurring in the early data collection and refinement stages, can have significant impacts on later decisions based on the data.

Specific Instance of Problem

The domain of particular interest in this study is the emergency resource command and control center, commonly called the emergency operations center, or EOC. Generally, these facilities are tasked with directing a semi-fixed set of resources (police/fire/medical) to incidents occurring within a specific geography. The inventory levels of the various resources
are based on historical data and are set according to expected needs. This results in a system
which operates quite well for routine conditions. However, as environmental complexity (event
frequency, severity, etc.) increases, the information systems utilized to guide the emergency
response decisions may suffer due to failures at the lower-level data collection and refinement
stages.

Emergency response command and control personnel must maintain their own
individual mental models of the environment, while also recording changes in the environment
so that others may share or aggregate their views. Data regarding the environment arrive
through a variety of pathways, very few of which are digital. The majority of environmental
data arrive in analog formats which are too complex for current digital technologies to reduce
to essential model elements. (Harrald & Jefferson, 2007)
Figure 9, above, is a representative image of a small emergency operations center used for directing emergency services to incidents associated with large sporting events. The photograph shows two police telecommunicators, a video surveillance system operator, and an emergency medical services telecommunicator. Close inspection of the police telecommunicator at the center of the photo, indicates that he is wearing two separate portable radios, and is speaking on the telephone. The video system operator has access to more than twenty-five cameras throughout the facility, some of which have pan-tilt-zoom capabilities. The video feeds are directed onto the array of four monitors, two of which are

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1 This photograph was taken by the author while visiting the emergency operations center directing football game-day emergency response at Penn State’s Beaver Stadium in the fall of 2007.
duplicated on the ceiling-mounted monitors. A pair of laptop computers allows access to web-based information such as weather reports and surrounding traffic conditions.

The varieties of information channels into and out of an emergency operations center (EOC) make them very noisy environments. This goes beyond simply being loud. To an unaccustomed observer, it can be difficult to follow the activity related to any single event, due to all of the interfering sounds generated by other, not directly related, events. This is significant because in times with multiple simultaneous incidents, most of the communications occurring within the EOC is in the form of human speech, which must be interpreted in context. A message related to one incident may easily be errantly interpreted in the context of a separate incident.

Abstracted Description of Problem

As data arrive into the EOC as audio messages, the words must be translated rapidly and accurately, and their description of effects on the environment assessed. In centers where more than one person operates, a model of the environment must be shared. This requires the recording of the environmental changes into a sharable medium. In a previous investigation (Jones, 2004), the author interviewed administrators and operational personnel, and spend several hours observing the operations, in a diverset set of four emergency operations centers in Pennsylvania. Two were busy sub-urban centers outside of Philadelphia, one was in an extremely rural area of northeastern Pennsylvania, and one was in a mid-sized facility serving a primarily rural area, but with a single large population center. A surprising finding was that
while EOC personnel record environmental activity into databases, there was very little real-time aggregation, analysis, or sharing of the recorded data. Only one of the visited centers had real-time aggregate information regarding the entire geographic region. That center did not use computer-based systems for activity tracking. Instead, time-punch cards were used to record the assignments of resources to specific incidents. Each card was marked with an incident number and a resource identifier, and time-stamps recorded the changes in each resource’s status as they progressed through the incident. The cards related to each active incident were stacked together on a countertop shared by the telecommunicators. At any time, anyone could see how many incidents were being handled by counting the stacks of cards; and they could assess the severities of the incidents by looking at the number of cards in each stack. In the three centers visited during this study where computer-aided dispatch systems were used, there was no facility for an objective real-time report of the number of concurrent incidents, or their severity.

Through these studies, a high-level schematic of the elemental functions of emergency operations centers was constructed, and is shown in Figure 10, below.
The functions of the emergency operations center can be broken into three basic interrelated categories: communications, situation monitoring, and decision-making. Of course, this model is generic enough to apply to most command and control environments, but it breaks communications out as distinct cross-operational function. Arranging the function categories this way and showing the information flow patterns between them, allows for focus to be brought onto specific information pathways. The explicit separation of communications is intended to represent the augmented complexity of unformatted voice messages as compared to simple data feeds. The additional complexity arises from the involvement of untrained laypersons as sources of raw data.
Figure 11 conceptually illustrates the failings of the computer-based information systems observed in the Beaver Stadium emergency operations center, and the regional emergency operations centers visited in 2004 (Jones, 2004). The interviews and observations made during those visits revealed the primary purpose of data collection in those centers to be ongoing basic statistical analysis, usually performed on a month-by-month basis. The managers of the centers had all stressed to the telecommunicators an emphasis on accurate reporting of activities, especially during busy periods. In effect, the centers all required their personnel to pay extra attention to the reporting requirement precisely at the times when their attention was demanded by external events.

The diagram, which is conceptual in nature and does not have precise units of measure, shows that as the situational complexity (number of concurrent incidents, speed of message...
arrival, etc.) of the environment increases, the current information systems become less helpful. Assuming that the information systems have some positive real-time functional utility under normal conditions, there is a point where the data-entry requirements of the system exceed the real-time value of the system, and the data-entry requirements become more of a hindrance to performance than a help. The desired utility curve is at least as good as the current systems’ and ideally improves performance as situational complexity grows.

The phenomenon of the downward sloping utility of the emergency operations center information systems was most obvious in the data collection tools used by the Beaver Stadium center’s emergency medical services telecommunicators. On several occasions, when there were multiple simultaneous responses to coordinate, the personnel were observed to discontinue the use of the computer-based tools and switch to basic pen-and-paper record keeping. When activity slowed down, they would enter the data into the computer from the hand-written notes. When they were asked about this, the dispatchers explained that the data were only compiled at the end of season to determine if more medical teams might be needed, and where they should be positioned.

**Information Flow Models**

An overview diagram of information flow through a typical emergency operations center might look something like this:
The flow process is of course cyclic, operating upon and within a specific environment.

The central process (interpreting information, extrapolating meaning, forecasting, and composing directives) is representative of the “human-in-the-loop” concept. Each of those process elements are (here defined as) anthropologic in nature, though they may be assisted by recursive loops acting, with technologic assistance, on more and more fine-grained data.

**Specific Sub-Models for Investigation**

**For investigating the capabilities of participants to interpret and refine data:**

Data → Information → Extrapolation → Data

Data arrives to a waiting person who must transform the data into useful information, extrapolate the meaningful pieces, and then convert them into new data by recording the extrapolated meanings through a human-computer interface. In the specific instances of the proposed experiment, data will arrive as audio messages, which must be transformed into information, and refined into a simpler form of data for entry into a database.

**For investigating the capabilities of participants to establish situational awareness:**

**SUM (Data → Information → Extrapolation), over a number of iterations**
Cycles of data arrival and interpretation will allow a person to build and maintain a mental model of the changing environment, which will in turn be used in subsequent data interpretations.
UNDERSTANDING

Overview of the Emergency Response System

The Emergency Response System under Normal Circumstances

There are more than 6,100 emergency operations centers in the United States, handling approximately 240 million calls for assistance each year. (NENA, 2009) Despite these numbers, and that the emergency services domain is considered to be a component of the national critical infrastructure, it is an under-researched area, particularly in its ability to handle extraordinary circumstances (Rhodenizer et al., 2000). Previous research on the emergency medical services' (EMS) response to extraordinary incidents have cited the access to accurate and timely information as a mitigating factor in the effective care for victims of mass casualty situations (Beyersdorf et al., 1996)(Feliciano et al., 1998). In these case studies, the focus was on the proper triage and transportation decisions affecting actions between the scene and the destination hospital. Many of the same principles apply to the allocation of EMS resources to the incident itself. The improved timeliness and accuracy of information related to more typical emergency incidents has been shown to positively impact the outcome. A study of Pennsylvania’s adoption of Enhanced-911 (Athey & Stern, 2000) concluded that the additional automated information acquisition was able to boost the survival rates of pre-hospital cardiac patients.

The emergency response system may be broadly broken into two segments: (1) The emergency operations centers (EOC’s), which function as command and control, and (2) the field-based emergency responders.(Lindell et al., 2006)
The most fundamental task of an Emergency Operations Center (EOC) is resource allocation. There are two essential bodies of information required to accomplish this task: needs assessments and resource availabilities. In the context of an EOC, needs are assessed primarily through telephone calls arriving via the 911 system. Additionally, radio communications with field responders may indicate new or changing needs within an already recognized incident.

Emergency responders may operate capably in multiple capacities, but most have a single “home” service. The most common types of emergency response services are:

- Police – with the dual responsibilities of maintaining order and investigating criminal activity
- Fire / Rescue – fire suppression and control, the extrication of victims from hazardous conditions
- Emergency Medical Services – which provide varying levels of medical care to victims of trauma and acute medical conditions
- Hazardous materials containment and clean-up
- Search and Rescue – which can be specialized for specific conditions (e.g.: mountain rescue, water rescue, etc.)

The relationships between the service types can vary greatly from region to region. In some areas, each service type may be independent of the others, and in other areas some services may be incorporated into larger organizations. For example, it is not uncommon for basic hazardous materials response to be a component of a fire department. Furthermore,
some services have limited or specific scopes of operations, such as fire response organizations which operate exclusively on the grounds of airports.

The standard unit of operations in the visited EOC’s is the incident. An incident is initiated by one or more calls to the EOC representing a situation which requires the intervention of one or more of the services controlled by the EOC. An incident is usually limited to a specific location and primary type: illegal activity, medical problem, fire, etc. The information systems currently used by the EOC personnel reflect the central role of the incident. From a computer display of a single incident, it is possible to determine which resources have been assigned to that incident, and their current level of involvement (dispatched, responding, at the scene, etc.) with the incident. Some of the systems provide a display of the activity of any one resource for some period of time. That is to say that one can learn of the incidents with which a single resource unit has been involved.

Many academic treatments of the domain of emergency response advocate the implementation of new or improved technologic systems, but do so with a very limited view of the true applicability to the reality of field operations. Yee offers a short, pointed description of some of the problems facing information systems’ use in times of unusual stress and situational complexity. (Yee, 2001) In the immediate wake of the September 11th attacks, Yee and a colleague deployed a web-based system for collecting information about survivors to help satisfy the nationwide thirst for information concerning specific individuals. The problems they encountered ran the gambit from publicizing the service to figuring out how to properly handle
errant submissions to their database. Many of the data coordination problems they
encountered were derived from the unofficial nature of their, and others’, operations, and the
supply of raw data from non-professionals.

Crow & Jonson, from Pennsylvania State University’s Applied Research Laboratory,
developed a medical information communications system utilizing handheld computers. Their
final report on the project revealed a minimal utility for ambulance-to-hospital
communications, but an unexpected utility for accurate record keeping. (Crow & Jonson, 2001)
Rather than using the handheld systems as a data gathering and communications mechanism
while enroute from the scene of the medical incident to the hospital, the systems were used
after leaving the hospital to begin the written record. The field personnel who tested the
prototype reported that while the handheld computers and the software were not difficult to
use overall, they were not easily utilized in situ, when other tasks had priority and
communication could still be achieved by voice over radio means.²

Phelps, Wagner, and Guralnic, from Honeywell Laboratories, describe the use of
handheld computing devices as a decision support aid for firefighters while engaged in the
business of fighting fires. Within their discussion of potential uses of their system, pre-incident
planning based upon longitudinal data collected by the system is a major point. (Phelps et al.,

² The author has had several informal discussions with users of the prototype system, many of whom
agreed with the sentiment that the system worked well in situations where the information was not critical (e.g.: minor injuries), but the pace of activity in a more serious situation, and/or a short transport time, precluded the use of the system as it was intended. Furthermore, by personal experience anecdotes, the value of the additional information encoded into voice communications via tone and conversational pace can be demonstrated. This is a ripe area for further research.
They present a system with a generalized strategic conceptualization demonstrated by a very specific tactical case. It is not clear from where the tactical task definitions would be derived in an actual field deployment. For example, the screen-shots of their software application list “check adjoining hallway” as a task with associated timing and other parameters. There is no indication how the software would know that an adjoining hallway exists.

A similar effort by Betts, et. al., from NASA’s Ames Research Center was demonstrated to field responders. They report that through there were several features the field personnel appreciated, they also had several reservations. One responder reportedly stated that “no matter how advanced the tool, he would never leave his pencil and notebook behind.” Again, the potential utility as a record-keeping mechanism rather than as a real-time decision support system was mentioned. (Betts, 2005).

The basic failing of these proposed system designs comes from a lack of understanding of the target operating environment. This is not entirely the fault of the researchers, who were approaching the problem on a data processing and communications level. What was neglected, by the “domain experts” as well as the researchers, was the operational context of the proposed system, and how the variables within that context affected the value of the information: When the circumstances permitted the use of the technology, the information was not very important; when the information was important, the use of the technology was not practical.
Other examples, such as the 1992 London Ambulance Service’s failed deployment of a new computer-aided dispatch (CAD) system dramatically demonstrate both the criticality and complexity of some information systems. (Finkelstein & Dowell, 1996) The new system was planned to be a leap forward in the automation of emergency ambulance dispatch. Instead, within hours of becoming active, the system began experiencing major problems and was eventually shut down completely. The incident is described as an example of a systemic failure, rather than a failure of any one piece (Finkelstein & Dowell, 1996).

Knight includes the London Ambulance Service incident with several other examples, including some from the nuclear power industry, to demonstrate the need for well-constructed “safety critical systems.” (Knight, 2002) The fundamental problem cited in these systems is communication failures between engineers involved in their design and construction. In the absence of accurate communication, incorrect assumptions are incorporated into system designs, leading to failures. One of the most memorable examples of this phenomenon is the Mars Climate Orbiter crash, caused by incorrect assumptions concerning the units of measurement used in navigational calculations. (Knight, 2002) (Leveson, 2004)

As in many instances, the ability to make proper decisions regarding the allocation of resources, whether they are supplies or manpower, depends greatly on the quantity and quality of information reaching the decision makers. In some areas of practice, it is beneficial to delay the commitment to a particular course of action while additional information may be gathered and processed. Depending on the specific situation, it may be possible to put off the
allocation of resources for months or even years with no significant ill effects. The very nature of emergency response, however, precludes the ability to delay decisions; and large-scale emergency responses make this practice even more harmful. In a large-scale emergency response, the question which must be addressed changes from “which resources are needed?” to “which incidents need which resources MORE?” The information required to properly respond to this expanded resource-allocation question must be greater in volume and quality, and must be processed as quickly as possible.

A noteworthy passage from a discussion of planning activities states that “Evaluation occurs within the development of the plan, and we found that members of the planning staff take the responsibility for questioning the plan or pointing out discrepancies within it. Therefore, computer-based planning systems that generate plans automatically cut out this vital linkage with the human planners.” (Miller, 2001) While it is beyond the scope of this work to investigate the advances in artificial intelligence which may provide for the self-criticizing activities implied by this statement to be important, the point that a “linkage with the human planners” is described as “vital” is relevant. A key design consideration for the human-computer interaction capabilities of a decision support system, whether it is for an individual user or some group, is its ability to communicate the potential negative effects of a decision, as well as the expected positive effects. This information may become more crucial when the decision at hand is expected to minimize the negative while accepting that it cannot be eliminated altogether.
The Emergency Response System during Extraordinary Events

In the wake of the attacks of September 11\textsuperscript{th}, hurricane Katrina, and other extraordinary incidents, the United States’ Department of Homeland Security established the National Incident Management System (NIMS) as a set of standard operating procedures to guide the response coordination for such wide-scale events.\textsuperscript{(US-DHS, 2008)} Under the premise that emergency operations must remain consistent across various response scales or will likely not be utilized \textsuperscript{(Turoff \textit{et al.}, 2004)}\textsuperscript{(Turoff, 2002)}, the NIMS guidelines are applicable to normal day-to-day operations as well as to atypical events.

When the emergency response capacity of a region is exceeded by the need for resources, NIMS triage protocols go into effect to help guide the decision making process. Such circumstances highlight the recognition of the emergency operations center (EOC) as the coordination point of a large and diverse system of individual entities. \textsuperscript{(Bostick \textit{et al.}, 2008)}\textsuperscript{(Chen \textit{et al.}, 2008)} An integrated EOC utilizes the protocols established by NIMS and other guidelines, along with information regarding resource capability and availability to make assignment decisions regarding needs reported from a particular region. The pace and severity of such reported needs may be fairly routine, but may scale suddenly and unexpectedly to overwhelm resource capacity.

In the emergency operations center domain, a critical incident is considered to be any set of circumstances that increases the likelihood of loss of life, wellbeing, or property, to unusually high levels. It may be thought of as a set of conditions where some loss must be
accepted as unavoidable and resources must be managed with such expectations in play. A typical example of this would be a mass-casualty incident (MCI), which involves multiple people who require medical treatment for injuries of varying severity. (Branas et al., 2000) Often, the mechanism of injury includes circumstances which require other emergency services to become involved simultaneously. Incidents such as multi-vehicle accidents may result in such conditions. The process of allocating resources to provide care becomes a much more challenging problem.

**Command and Control Systems**

**The OODA-Loop**

The literature describing military command and control practices is dominated by Boyd’s Observe-Orient-Decide-Act (OODA) loop framework.\(^3\) (Boyd, 1996)\(^4\) The so called “OODA-loop” has been a recognized and employed by military decision-makers for more than a quarter century, and has spawned several variants. (Hammond, 2001) In essence, the OODA-loop is a set of iterative evaluation and action processes contained within a larger iterative structure. See Figure 12, below. The OODA-loop provides a fundamental framework of command and control stages which is generalized and flexible enough to see application in a wide range of domains and scale. Boyd surmised that the success of U.S. Air Force pilots against adversaries with aircraft which were technically superior in many ways was largely due to the U.S. pilots’

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\(^3\) Google reported “about 40,400 results” for the terms “OODA loop”; “about 21,300 results” for the terms “Boyd’s OODA loop”; and “about 88,500 results” for the exact phrase “Boyd’s OODA loop” – Google SRP, August 29th, 2010

\(^4\) Boyd did not publish a conventional paper or book containing his OODA-loop description. His work was presented in the form of verbal briefings with accompanying slide sets. (Grant, 2005)
ability to work through the OODA-loop at a faster pace. In effect, he reduced the skillset needed to control a military aircraft to a subset of what was needed to be successful at it.

Boyd’s original concept of “observe, orient, decide, act” has been used as a foundation, and modified by several researchers and practitioners. The Dynamic OODA-loop (Brehmer, 2005) and the Cognitive OODA-loop (Breton & Rousseau, 2008) are some recent examples. Brehmer’s work expands the basic OODA-loop components by focusing on military decision-making and decomposing those activities into sub-units. One of the concepts introduced in the Dynamic OODA-loop is information collection and sense making in the context of a specific command concept. Brehmer also made it a point to explain that the term “sensors” could be applied to people who refine and filter raw data before passing it on to the commander. Breton

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Image retrieved from http://strategy4sustainability.files.wordpress.com on June 19, 2010

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and Rousseau’s Cognitive OODA-loop is an extension of their earlier work, the Modular OODA-loop (Rousseau & Breton, 2004), and integrates Endsley’s model of situation awareness (Endsley, 1995)(Endsley, 2000) as well as Klein’s recognition-primed decision making model (Klein, 1988)(Klein, 1993) into the OODA process. The cognitive construction of situation awareness as described by Endsley is seen as the extension of the “observe” and “orient” segments of the OODA loop, while Klein’s recognition-primed decision making model fills out the “decide” and act segments.

One of the most emphasized elements of the OODA-loop is the concept of pace. (Brehmer, 2005)(Curts & Campbell, 2001) From the prevalence of discussion on the pace of information gathering and analysis, the importance of timely, as well as accurate, information may be inferred.

The SHOR Model

The Stimulus-Hypothesis-Option-Response (SHOR) model (Whol, 1981) was introduced in the early 1980’s and shares many features with the OODA-loop, though there is no indication that Whol and Boyd were aware of one another (Grant & Kooter, 2005). As with Boyd’s OODA model, the component processes of SHOR are meant to be iterative and self-reinforcing via feedback loops. The top-level components of the OODA and SHOR models do not map one-to-one, but overlap. Whol’s model includes a set of sub-processes within each of the top-level designations. These sub-process definitions provide a much more detailed view of the
interactions within each major section, in the same way that later additions to the OODA model did.

![Figure 13 - Whol's SHOR model; image from (Grant & Kooter, 2005)](image_url)

Comparing the OODA model in Figure 12 and the SHOR model in Figure 13, it is possible to see virtually the same chain of activities, beginning with the collection of raw data, the transformation of that data into information, a decision process, and an implementation stage. Each component of the model is linked to others, providing a feedback mechanism. Table 1, below, lists the sup-processes of the SHOR model and maps the components to those of the OODA model.
Whol’s SHOR model, including sub-processes

<table>
<thead>
<tr>
<th><strong>Stimulus</strong></th>
<th><strong>Relationship to Boyd’s OODA model</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gather / detect</td>
<td>Observe &amp; Orient – The description of the SHOR “aggregate” step, correlates with the OODA “orient” step. The “store/recall” step is not alluded to in the OODA model beyond vague mentions of “past experience.”</td>
</tr>
<tr>
<td>Filter / correlate</td>
<td></td>
</tr>
<tr>
<td>Aggregate / display</td>
<td></td>
</tr>
<tr>
<td>Store / recall</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Hypothesis</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Create hypothesis about situation</td>
<td>Orient</td>
</tr>
<tr>
<td>Evaluate hypothesis</td>
<td></td>
</tr>
<tr>
<td>Select hypothesis</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Option</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Create response options</td>
<td>Decide</td>
</tr>
<tr>
<td>Evaluate options</td>
<td></td>
</tr>
<tr>
<td>Select option</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Response</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plan</td>
<td>Act – Though the SHOR steps of “plan” and “organize” are not explicit in the OODA model.</td>
</tr>
<tr>
<td>Organize</td>
<td></td>
</tr>
<tr>
<td>Execute</td>
<td></td>
</tr>
</tbody>
</table>

Table 1 - mapping of SHOR and OODA model components - based on (Grant & Kooter, 2005)

Naturalistic Decision Making

In contrast to the decision refinement methods described above, recognition-primed decision making (RPDM) (Klein, 1998) is essentially a model to describe the decision processes of domain experts who do not utilize a formal multi-step decision-making model. Kein’s work has given rise to the field of naturalistic decision making (NDM) which, among other things, presumes a lack of complete situational information along with “high-stakes” decisions is a normal condition. Because of its reliance upon domain experts, much of the research in NDM is ethnographic in nature. There is, however, a growing interest in NDM with its implications in a wide range of fields. Malcolm Gladwell has provided several anecdotal accounts of rapid
decisions made by domain experts, as well as laypersons. (Gladwell, 2005) The case studies he presents run the range from extremely good decisions made with minimal data to extremely poor decisions made with access to extensive data. In the field of physical security, Gavin deBecker has published several popular works which echo Klein’s RPDM model. The principal assertion of deBecker’s works is that most people are unwilling to accept a “gut feeling” even in regards to a potentially dangerous situation. (deBecker, 1997) The effectiveness of the RPDM model therefore relies upon not just domain experts, but experts who have come to trust in their own rapid judgment.

Naturalistic decision making (NDM) and ecologic interface design (EID) are running themes in Kim Vicente’s book “The Human Factor” (Vicente, 2004) which provides several examples where human decision makers had access to comprehensive data, but it was not presented in formats that were conducive to the decision-making process. These examples provide motivation for constructing human-computer interface systems with the assumption that unusual and foreseen circumstances will occur.

Some additional alignment between the command and control models produced by the various cognitive science, cybernetics, and practitioner views is emerging through recent work in neurology. Hawkins & Blakeslee have proposed a “hierarchical-temporal-memory” (HTM) model as a step toward improved artificial intelligence systems. (Hawkins & Blakeslee, 2004) The HTM model is based upon the neurological structure of the mammalian neo-cortex and helps to explain several common, but subconscious everyday events. (e.g.: feeling compelled to
stare at disfigurements, slowing down to look at an accident even though it is not blocking your path, etc.) These events are all exceptions to most people’s normal experience, and so induce a hierarchical categorization (and learning) process to fit the observation into pre-established prototypical situations. This process is either an implicit (Boyd’s orientation stage) or explicit (e.g.: Klein’s “is this situation typical” criteria) element of command and control models.

An interesting perspective on command and control, including a very practically-oriented discussion of the problem of information overload, is presented in (Roman, 1996). The author argues that the improvements in information technologies over the past few decades are skewed toward faster data collection while decision making capabilities have not benefited by a similar improvement in capability. The proposed remedy to this problem is organizational change to enable more distributed decision-making processes.

Summary of Command and Control Modeling

A survey of fifteen command and control models (Mayk & Rubin, 1988) was cited and supplemented as part of an effort to streamline command and control processes in support of software development. (Grant & Kooter, 2005) These works clearly show how the most common models of command and control decision making can be mapped to one another. In fact, Mayk & Rubin describe a “buzz-word generator” which can produce over seventeen thousand different command and control models by recombining the various terms used to describe the stages of data gathering, analysis, and decision-making.
No matter which model of command and control is favored, they all have a common opening theme: the gathering of data. Boyd called this the “observe” step. Whol called it “stimulus.” Rasmussen used the term “Perception.” Klein describes “acquiring information about the situation.” The collection of accurate and timely intelligence regarding the state of the environment is an obvious necessary precursor to any decision-making process.

Aschenbruck, et. al. discuss a complimentary concern to the availability of environmental data: the quality of the data. (Aschenbruck et al., 2006) While situational data quality is usually implicit in the discussions of command and control, so is the technologic collection and communication of the data. These implications reduce command and control data intake to a non-anthropologic system of the kind described by Shannon (Shannon, 1948) which includes the relative ease of developing quantitative performance metrics at recursively reduced stages of signal propagation. Work such as that documented by Bearavolu, et. al. demonstrate the gap in this area: real-time awareness of the command and control data intake system is presented as necessary in assessing the quality of the decision-support data, but the system is represented as a purely technologic artifact. (Bearavolu et al., 2003)

Situational Awareness as a Key Component of Command and Control

Definition of Situational Awareness

One of - if not the - most cited definitions of situation awareness is that of Mica R. Endsley’s: “Situation Awareness is the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection; of their
status in the near future.” (Endsley, 1988) This definition is broken into three distinct “levels” of SA, which Endsly gave the simplified names of perception (a.k.a.: “level-1 SA”), comprehension (level-2), and projection (level-3). Situation Awareness, in Endsly’s “decision model”, is one compound component among others, representing the cognitive processes iterating from the sensing of the surrounding environment through the action upon the environment. The relations among the various components are illustrated below in Figure 14. This diagram appeared in Endsley’s original 1988 paper and several subsequent discussions of SA.

![Figure 14 - Endsley's Model of Situation Awareness within a Decision Model (Endsley, 1988)](image_url)

One of the key elements of SA is that it can only exist within a human mind. (Billings, 1995) This feature establishes SA as an anthropologic construction which may be supported or
manipulated through various technologic means, but cannot be constructed by nor contained within technology. Some attempts are underway to develop technologic systems which work more intimately with SA elements (Matheus et al., 2003). This kind of work, however, boils down to the quest to better represent SA elements as digital artifacts, which suffer from lossy translation from the analog real world.

Some definitions of SA explicitly include observable external action. (Dalrymple & Schiflett, 1997) This is noteworthy since such a definition would allow direct objective observation to form the basis of an SA assessment method. Observable action, however, removes SA from the nest of the human mind, and requires additional mental processing to formulate a response plan, followed by a visible action. Such a definition would become very troublesome under conditions where a subject properly could not, or should not, take any action.⁶

Measurement of Situation Awareness

The “Critical Incident Method” was developed by Flanagan in the 1950’s as a technique for investigating aircraft pilots’ thought processes. Flanagan described critical incidents as “...extreme behavior, either outstandingly effective or ineffective with respect to attaining the general aims of the activity.” (Flanagan, 1954) Flanagan’s technique, which has been widely applied in cognitive engineering research, relies upon post-hoc evaluations of information deriving from extreme events or imagined worst-case scenarios. There is an implicit assumption

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⁶ Can a paralyzed person be aware of his situation? What if you were to suddenly be surrounded by poisonous snakes - you would be aware of your situation, and that awareness would lead you to be very, very still.
that future incidents will not be so novel as to defy categorization within the frameworks produced by the technique. Refinements of Flanagan’s techniques have allowed the basic procedures to adapt to other domains (Fountain, 1999) (Xiao & Mackenzie, 1998). Angelides makes a case that critical incidents are not necessarily “sensational events involving a lot of tension.” (Angelides, 2001) Though Angelides was considering a context very different from Flanagan’s, classrooms rather than cockpits, this assertion is supported by others. (Wong et al., 1997)

The Situation Awareness Rating Technique (SART) utilizes an evaluation model based on information supplies and demands, along with a measure of “understanding.” (Selcon & Taylor, 1990)(Taylor, 1990) The technique is subjective, requiring post-hoc evaluations of SA by study participants. This subjectivity of the SA assessment is the primary detractor from its use. (Endsley et al., 1998) The division of the model is suited to review after a scenario has played out. The information availability and demand components may be much clearer after the fact, when a complete contextual picture is available. This approach may also be useful for determining the appropriate emphasis of available information cues in a simulation – again by having an assessment of the information’s importance in a broader context. SART’s “understanding” component may be viewed a similar to level-2 SA in Endsley’s model.

Performance-based measurement techniques of SA (Pritchett et al., 1996) utilize the actions of subjects as proxy indicators of their SA. Proponents of performance-based assessment point to the failure of alternate techniques to extend from mental models (a.k.a.
knowledge-based) of SA to real-world application of SA. There are several examples of conditions where performance-based metrics outshine knowledge-based model assessments. Many of these, however, identify problems in the planning stages subsequent to SA formulation and imply the consideration of broader knowledge (e.g.: protocols and data confidence). This additional knowledge can be viewed as being integral to the SA formulation process, and not a later additive. In fact, it would seem that Endsley’s Level-3 SA would require such a higher-level view of the situation at hand, if accurate predictions are to be made. Furthermore, while it is logical that the purpose of building SA is for the development of action plans, SA is not a requirement for decision-making and action. It would be possible for a performance-based metric experiment to be tainted by a few “lucky” subjects. Conversely, a subject with adequate SA may be stymied by a flawed decision-making process or a poorly designed control interface. There is also potential for the subjects to bias the experiment outcomes if they are aware of the nature of the assessment metrics – they may act prior to formulating a properly thought-out plan.

The desire to objectively assess a subject’s SA is the obvious driver behind performance-based techniques. Similar assessment techniques based on “activity theory” have been studied by Bedny and associates. (Bedny & Meister, 1999)(Bedny & Karwowski, 2003)(Bedny & Harris, 2005) Activity theory has its roots in the former Soviet Union where it had been applied to understand situations similar to those addressed by western critical incident analysis techniques. The crux of activity theory is the progressive decomposition of observable actions
into more and more detailed and less objective sub-units of action. The decomposition is similar
to Rasmussen’s abstraction hierarchy (Rasmussen, 1986), but relies on finer-grained
descriptions of action – physical or mental – and avoids abstraction altogether. Also, whereas
Rasmussen has defined guidelines for a reasonable depth of the hierarchy, activity theory has
no such constraints. The focus of activity theory upon observable action is explicit in the name,
and so de-emphasizes the formulation of situation awareness in favor of a much more rigidly
structured representation of information and work processes.

Mica Endsley presented the Situation Awareness Global Assessment Technique (SAGAT)
in 1988 as an alternative to other methods in use at the time. (Endsley, 1988) The basic
procedure requires the pausing of an ongoing simulation, the blanking of all user displays and
other data channels, and querying the user with questions designed to gauge their awareness
and understanding of the simulated environment. The primary benefit of SAGAT is its
measurement objectivity. With displays blanked, questions can (and should) be presented
within the context of the simulated environment. With questions designed to assess the
subjects’ SA across the three levels of Endsley’s model, a complete picture of in-situ SA can be
drawn.

During SAGAT assessments, the simulation is suspended, displays are cleared, and
subjects are queried for indications of all three levels of SA. The need to suspend the action is
one of the drawbacks of SAGAT since this precludes the technique’s applicability to live
environments. A workaround procedure uses simplified real-time querying of subjects; wherein
individual questions are posed over a greater range of time while the subjects continue through their routine. (Jones & Endsley, 2000) These so-called “real-time probes” are certainly less intrusive, but may also be less accurate in their results (if the interest is in real-time internally-held SA), and the procedure is limited in the conditions in which it can be utilized. The use of real-time SAGAT probes may provide more realistic data, as subjects would be able to respond to queries by accessing current data and extrapolating an answer, as would occur in a real-world interruption by a supervisor.

**Situation Awareness and Ecologic Interface Design**

Systems can be categorized by their position on a spectrum ranging from the strict enforcement of a set of structured rules to the ability to adapt to support novel situations. The extremes of this spectrum are referred to as intentional systems and natural or ecological systems. Hajdukiewicz, et.al. presented the model which places the two types of systems as the extremes of a continuum, linking a system’s intentional constraints with its causal (ecological) constraints. (Hajdukiewicz et al., 1999) All work domains, and their associated information systems, would exist somewhere along the continuum.

Ecological Interface Design (EID) (Rasmussen & Vicente, 1989) has been developed to address the needs of constructing human-computer interfaces for complex socio-technical systems. The purpose of ecological interfaces is to support human decision-making, particularly in atypical and unanticipated circumstances. EID uses abstraction hierarchies as fundamental models describing system’s high-level goals related to the lower-level implementation details.
Interfaces built with consideration to the progression of abstraction to the overall goals of the system are able to provide their users with information and controls relevant to that overall goal, rather than all of the details of physical implementation.

Ecological interfaces are constructed to focus on the use of a system to achieve the overall purpose of the work the system is designed to support. An important piece of the EID construction process is gathering information of “the work domain (work space or problem space) as an integral component of the ‘cognitive system.’” (Flach et al., 1998) The importance of a proper understanding of the work domain is addressed in the same work: “… The limitations of technologies, humans, and control systems are important considerations --- but the significance of these limitations can only be appreciated relative to the functional demands of a work domain.”

Ecological interface designs have consistently been shown to improve the performance of systems, but this improvement is most apparent in non-routine operations, where humans are called upon as “knowledge workers” able to adaptively process the information coming through the interfaces.(Vicente, 2002) In Vicente’s example of a pasteurization process control system experiment, it was noted that while performance during unusual circumstances improved, performance during normal operations was unaffected by the use of EID. This is mentioned to show that the use of EID is not meant to trade normal condition capabilities for improved capabilities in atypical conditions. Little effect on normal operations is expected.
through the use of EID, while atypical operations are expected to become easier to understand and handle.

**Emergency response command and control contrasted with some other areas**

**Air-traffic control**

Domain analysis studies and other research of the field of air-traffic control show it to have some similarities with emergency response coordination. The vital nature of the information handled in air-traffic control environments promotes the consideration of safe information handling practices, even with consideration for multiple system failures. (Mackay, 1999) Furthermore, the expectation of encountering new and unforeseen events is present, and plays a role in training and practice exercises. (Grant, 2005)

The development of human-computer interfaces to support air-traffic control operations is an ongoing task. Palmer, et. al. have experimented with variations in flight information visual representation as a means to improve air-traffic controllers’ situation awareness. (Palmer et al., 2008). Their experiments provided a series displays with aircraft altitudes represented by sizing and shading icons, rather than using the traditional numeric-text displays. Subjects were asked to identify potential interactions (i.e.: in-flight collisions) and showed that even a simple change in how the critical information is represented can have significant impacts on overall outcome.
Emergency medicine

The field of (in-hospital) emergency medical treatment has several obvious similarities to aspects of (out-of-hospital) emergency response systems. Foremost are the high-stakes goals of both environments. Secondly, and in contrast to air-traffic control’s preventive operations, is the response-based nature of the domain. Responding to immediate life-threatening elements of an environment can require the processing of tremendous volumes of information, particularly in large-scale catastrophic situations. (Bowers III & Prochnow, 2003)(Bostick et al., 2008)(Burkle, 2002) Responding to events, as opposed to avoiding events, requires a continuous cycle of preparation, even while events occur and are dealt with.

Prior Research in Emergency Response Command and Control

An analysis of the numbers and timings of requests for assistance in the San Francisco Bay area was performed as a preliminary step to producing an accurate predictive simulation. (Jasso et al., 2007) The analysis found that there is a great deal of variation in the parameters describing the emergency needs of the region. (Harrald & Jefferson, 2007) make a strong case that a while shared operational picture is a necessary element of successful emergency response management, achieving the level of distributed situational awareness necessary is a very difficult task. This sentiment is reinforced by (Jennix, 2007) which provides some historical background and concentrates on the management of information as the level of coordination is scaled from local to national levels of service. It is important to note that each of these works discusses the complexity of the emergency response command and control domain using
examples drawn through data, but do not address the sourcing of that data for real-time operational use.

(Carver & Turoff, 2007) explored several aspects of the emergency planning and response management domain and produced a general guide for developing emergency response planning and control systems, explicitly including computer-supported communications systems. Their recommendations are summarized in Figure 15 below. Note that their framework includes similar command and control system components, in an iterative structure, to those discussed previously. Dr. Turoff has a long history as a proponent of computer-supported collaboration for the management of emergencies; see (Turoff, 2002)(Turoff et al., 2004). Again, the focus of these contributions is on the sharing and manipulation of information with little consideration for the formatting of the raw data.

![Figure 15 – HCI guidelines for emergency response information systems, from (Carver & Turoff, 2007)](image-url)
One excellent study of the emergency medical dispatch domain, taking place at the London Ambulance Service, was produced by (Furniss & Blanford, 2006). However, in concentrating on the flows of information within the emergency operations center, and in particular to the collaboration among resource allocators, the entry of new requests for assistance is not included. The authors explain: “Call takers are situated in a different area from the sector desks as they do not have to have direct contact with the sector desks. The floor to the call taker’s area is on a lower level than the sector desk area. This adds a further degree of distinction between the two and could help prevent sound travelling.” (Furniss & Blanford, 2006) This statement describes a common feature of the literature regarding emergency operations: call-takers are seen as a distinct, and sometimes separated, component of the system. The focus on the collaboration by resource commanders who will utilize environmental data, with little if any discussion of the sources of that data, is a common theme in the literature.

A simulation framework called RimSim (Campbell et al., 2008) has been used as the basis for an emergency operations command and control simulation with the ability to scale from single-player to multi-player modes, and thus explore distributed cognition in emergency response coordination using a single tool. They describe a single response scenario which is presumably scripted and embedded into the simulation.

(Jain & McLean, 2003) proposes a common framework for linking several simulation systems in an effort to more realistically prepare for large-scale, distributed events. This work
was supplemented by a proposal for establishing a shared library of disaster scenarios from which simulation-builders could draw. (Jain & Mclean, 2008)

(McGrath et al., 2005) used the example of online multi-player games as a basis for constructing an emergency response simulation system and demonstrated the efficacy of using relatively simple components to achieve realistic simulations.

(Wright & Madey, 2008) strove to make distributed computer-supported collaboration simulations of emergency operations centers more realistic by including communications anomalies which can disrupt the order of message arrival. The goal of this work is to evaluate the needs for and effectiveness of script-driven supplements to human collaborations in time-sensitive situations.

(Phelps et al., 2003) have built emergency operations simulations on the Task Analysis Environment Modeling and Simulation (TAEMS) agent framework. Although the simulations they describe include a comprehensive set of domain roles, there is no mention of the communication efficiency between the agents in those roles.

The NeoCITIES simulation system implements an emergency response management interface which can be scaled to engage decision-makers at multiple levels, and do so in a controlled network fashion. (McNeese et al., 2005) The scaling and networking capabilities of this tool make it well suited for explorations of decision-making processes where variations of the experiment participants and their interactions can be
controlled, revealing subtle advantages and disadvantages which other systems could not. This is the goal of the “living lab” approach (McNeese et al., 2000) which has guided the development of NeoCITIES.

In each of the systems discussed above, the focus is on the decision-making process and so the raw data is a controlled variable of the experiments being performed with them.

The gap between the research environments and the operational reality arising from the reliance upon voice communications.

Emergency operations centers are relatively unique in their reliance on voice communications with mixture of trained and non-trained people as their primary form of data collection. In most discussions of data collection for decision support systems, the possibility of people acting as the initial sensors is at least mentioned. Table 2, below, compares three command-and-control domains across the dimensions of data sourcing, data attributes, and broad attributes of the command personnel/systems.
<table>
<thead>
<tr>
<th>Domain</th>
<th>Sources of data</th>
<th>Data attributes</th>
<th>“Commander” attributes</th>
</tr>
</thead>
<tbody>
<tr>
<td>military</td>
<td>• Multiple types and distributions of sensors</td>
<td>• Digital raw or refined data from a variety of sources</td>
<td>• Are often removed from the raw data and therefore base decisions on refinements made by subordinates and technology-driven data fusion systems.</td>
</tr>
<tr>
<td></td>
<td>• Forward observation personnel</td>
<td>• Observers are trained to refine and report data, minimizing ambiguity</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Radar w/ transponder identification</td>
<td>• Radar displays and radio conversations complement one another</td>
<td></td>
</tr>
<tr>
<td>air traffic control</td>
<td>• Radio communications with pilot</td>
<td>• Pilots are trained to refine and report data, minimizing ambiguity</td>
<td>• Have direct access to both digital and voice data sources, and can directly communicate with actors in the environment.</td>
</tr>
<tr>
<td>emergency medicine</td>
<td>• The patient</td>
<td>• Raw data can be drawn from a number of sources including digital displays and direct sensory perception, including touch and smell.</td>
<td>• Protocols have been established to guide the comparative weights of the distinct data channels, should they contradict one another.</td>
</tr>
<tr>
<td></td>
<td>• Digital monitors and displays</td>
<td>• Refined data are accessible through visual and voice engagements with other providers and the patient</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Direct observation with multiple senses.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Collaboration with other medical personnel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>emergency operations centers</td>
<td>• Field Responders</td>
<td>• Raw data are almost exclusively in the form of voice messages</td>
<td>• Usually have direct access to digital, voice, and visual data from other practitioners and the patient.</td>
</tr>
<tr>
<td></td>
<td>• Victims</td>
<td>• Only the field responders are trained to refine and report data; laypersons provide ambiguous data</td>
<td>• Conversations with patients can be directed to elicit specific information.</td>
</tr>
<tr>
<td></td>
<td>• Observers</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>It is not uncommon for the decision-maker to also be responsible for the reception and processing of the raw data.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Due to the data ambiguity arising from untrained and uncoordinated sources, efforts must be made to correlate reports quickly, in order to distill an accurate model of the environment.</td>
</tr>
</tbody>
</table>

Table 2 compares data and commander attributes across the three broad domains of military, air traffic control, and emergency operations coordination. The primary aspects which set emergency operations centers apart are derived from the fact that a majority of the data
regarding the operational environment, for both the affective and effective elements, are received as voice communications and much of those communications are sourced by people who are not trained to refine, filter, and report only the relevant pieces.

Within the “inference hierarchy” described by Hall and Llinas (Hall & Llinas, 1997), the emergency operations centers have a data fusion problem at the lowest levels. The inference hierarchy describes the increasing detail of information which can be inferred from increasing data volume and source diversity. The lowest level represents the ability to reliably determine that something simply exists in the environment. The hierarchy proceeds through information levels representing the location, identity, behavior, surrounding situation, and finally the threat posed by any environmental entity. For the emergency operations centers, the “entities” of concern are incidents occurring in the environment and the emergency response resources which can be allocated to those incidents. Due to the nature of the data coming into the EOC – verbal reports from untrained observers – assessing the location of an incident, and in many cases determining whether or not new data is referring to an already identified incident, can be difficult.

**Conclusion: the missing connection to the operational reality prevents the application of the research.**

Current research regarding the management of information and the decision-making processes in the emergency response domain largely center on:
1. The uses of technology for fast and accurate access to situationally relevant information such as the use of mobile devices by field personnel for in situ data capture and report-back to a centralized system. E.g.: (Crow & Jonson, 2001)(Phelps et al., 2003)(Betts, 2005)

2. The distribution of the decision-making process by sharing data and facilitating communication among groups of specialists spread over various levels of geographic dispersion. E.g.: (McNeese et al., 2005)(Jones, 2004)(Carver & Turoff, 2007)(Burkle, 2002)(Turoff et al., 2004)

3. The implementation of (semi-)automated decision support systems. E.g.: (Grant, 2005)(VanDeWalle & Turoff, 2008)(Potter & Wickler, 2008)(Chen et al., 2008)

The bodies of literature which cover multi-modal interface design, including those that discuss emergency response operations, tend to focus on the manipulation of information already contained within a computing system.

Much of the work in these areas pre-supposes the availability of situational information which may not be immediately available, especially in the digital formats needed for computer-assisted analysis or distributed collaboration. The reality is that the majority of the raw data entering the emergency operations center is held in voice communications, and many of those communications originate by untrained personnel, and are therefore not well suited to computer-mediated data collection. Furthermore, even if a computer-based speech recognition system could overcome the obstacles of speaker voice variations to produce an accurate stream of digitized text, the system would have to be interactive enough to direct the conversations through a highly variable set of contingencies and questions to provide an
adequate level of service. (Prinzo, 1998) discusses some of the problems encountered in the use of a speech recognition system in the air-traffic control domain.

Even then, the additional information represented by those very speaker variations (e.g.: speech speed, intonation, etc.) would likely not be captured adequately. The voice communications within the EOC’s are information rich, but data poor.
QUESTIONS

Overview

The goal of this research is to improve the understanding of one type of information processing which commonly takes place within emergency operations centers and is crucial to fulfilling their mission. That mission, in general terms, is to coordinate the assignments of resources to emergency incidents. The successful execution of this mission requires access to an up-to-date model of the environment being serviced. Any attempt to improve the decision-support capabilities of the EOC through automation must be concerned with the timely availability of accurate data arriving from outside the center. The majority of the data arriving at the EOC is in the form of voice communications. Therefore, the rapid interpretation of audio messages continues to be one of the most critical basic skills for emergency telecommunicators, and is also a skill not easily handed over to automation. Furthermore, the effects of message (mis)interpretations are most pronounced when resource utilization peaks; which coincides with substantial increases in message arrival rates. Errors which may have little or no effects under normal conditions may be very detrimental during busy periods. It is therefore desirable to develop human-computer interface designs which are able to support improved decision support during extremes in demand, as well as the usual day-to-day. Referring back to Figure 10 on page 12, a target area for exploration here can be painted over the intersection between communications and situation monitoring in the emergency operations center work domain.
A key milestone toward reaching the overall goal is achieving some understanding of the opportunities and constraints within inter-modal human-computer interface (HCI) designs. The term “inter-modal” has been coined to describe the situation commonly found in emergency operations centers, where incoming information arrives in the form of voice messages which must be interpreted and transferred into an information storage and distribution system in a non-audio format. The quick and accurate interpretation of incoming voice messages is a prerequisite for any decision-making process. The quick and accurate entry of those interpretations into a production database is a prerequisite for distributed and/or automated decision support processes.

A courtroom stenography machine contains an example of an intermodal interface. The stenography machine, however, is used to record data for later retrieval. Ideally, a decision support system, such as might be used in emergency operations centers, will integrate new data into an environmental model as quickly as possible so that decisions can be based upon near real-time conditions.

7 The term “inter-modal” as applied to information systems constructs is derived from its use in describing cargo transportation chains, where the mode of transportation is changed (e.g.: from ship to rail to truck, etc.). See (Ottjes et al., ) and (Harris et al., 2010).
There are many outstanding questions regarding the design of human-computer interfaces for inter-modal data handling. Focusing on the requirements of the selected domain of emergency operations centers, these two questions are at the point of the matter:

1. What elements of human-computer interfaces are able to influence the speed and accuracy of user-arbitrated capture of data arriving as voice messages?
2. What elements of human-computer interfaces are able to influence the mental construction and maintenance of situational awareness for domain conditions being reported primarily via voice messages?

Implications of these questions affecting experiment design

The speed of data entry and processing for decision support is irrelevant if the entered data are not accurate. Therefore, the combination of speed and accuracy must be assessed to determine the potential of any data collection interface. This is a more challenging scenario.
than those presented in typing tests or the like. The measurements of speed and accuracy are not simply manifestations of the physical abilities of a user to operate an interface because they include the requirement for some mental processing of the source material to determine what data should be entered through the interface.

It is the necessity for assessing this combination of performance measures which dictates the experimental approach. In order to assess the accuracy of a subject's entries, a constant and complete understanding of the environment must be maintained. Utilizing a realistic simulation system which provides the necessary metadata for comparison to subject-supplied data aggregations is the most straightforward method.

A further goal of the design of inter-modal interfaces for emergency resource allocation is the development and maintenance of situational awareness. This consideration arises from the common practice of having emergency telecommunicators be responsible for resource allocation decisions as well as requirement analyses.

The three interfaces which are part of the experiment described in this research all rely on a human component to perform the interpretation of incoming audio messages. Interface #1 implements a plain black text on a white background appearance, including text-only statistics of resource allocation data. Interface #2 adds color fields to distinguish between the three emergency service types: police, fire, and medical. It also provides the running allocation statistics as bar-charts in addition to text. Interface #3, adds a text transcription of each incoming audio message to the display, emulating a high-accuracy speech recognition system.
For recording the interpreted meanings of the messages, the interfaces all use simple mouse-based selection methods. All three interfaces share the same underlying visual layout to avoid the possibility of variations in cursor travel distance having an effect.

In addition to the basic interpretive speed measures, the experiment includes an assessment technique aimed at exploring the effects of the different inter-modal HCI designs on users’ situation awareness. Situation awareness must be built up over a period of time, and allows a person to describe the relative arrangements of environmental elements, as well as make short-term predictions of future states.

Refinement of research questions and speculative findings
Understanding the opportunities and constraints within inter-modal HCI designs.

Strategy: Measure and analyze the performances of a group of users operating a series of controlled interface designs, within a controlled test environment.

Tactic: Non-domain-expert users will utilize a series of computer interface variants to record information presented to them as audio messages. The accuracy and timeliness of their recording actions will comprise the major metrics.

Exploring the effects of different inter-modal HCI designs on users’ situational awareness.

Strategy: Measure and analyze metrics of users’ situation awareness as they operate a series of controlled interface designs, within a controlled test environment.
Tactic: As non-domain-expert users are utilizing a computer interface variant, the simulation will (as described in the SAGAT guidelines) periodically freeze, blank their displays, and pose a short series of questions regarding the current state of the simulated environment. Their responses, compared to the actual state of the simulated environment, will be the main metrics.
EXPERIMENT

Overview

Inspiration for this experiment was drawn from the work published in early 2008 by Palmer, Clausner, and Kellman (Palmer et al., 2008), which evaluated the effects of variations in visual information representations of aircraft within an air traffic control situation. In that study, subjects were asked to determine if an impending aircraft collision condition was present in each of a set of simulated air traffic displays. (i.e.: The objective measure was a single element of level-3 SA; levels 1 and 2 were not considered.) The displays were varied among four types, and served as visual situation representations only; the displays were not interactive. The conclusions of this study indicated that very subtle alterations in the design of information interfaces can have significant effects on the speed and situation awareness of their users.

Some further insight was provided by Pollak, Falash, Ingraham, and Gottesman, all from Lockheed-Martin, who constructed an emergency response simulation system using the Arena simulation tool. (Pollak et al., 2004) Their simulation included an emergency operations center as one component in an array of inter-related emergency response entities. The purpose of their work was to holistically model the response of a region to a particular type of incident. The scope of their simulation targeted only the single umbrella incident - an anthrax attack - and did not account for the continuation of the normal day-to-day operations, which were apparently eclipsed by the severity of the larger context.
Experimental Hypotheses

There are three hypotheses to be tested through this experiment:

1. Graphical user interfaces will allow users to more quickly and more accurately report the meanings of audio messages describing changes in the environment.

2. The addition of a secondary message representation mode will increase the accuracy of interpretation at the expense of speed.

3. Graphical user interfaces will better allow users to build and maintain a situation awareness of their environment.

Experiment Design – General

The operational conditions of an active emergency operations center (EOC) are very complex and fairly unique. This is true even though the operational requirements are straightforward: direct appropriate resources to reports of incidents based upon their priority.

The critical functions of emergency operations centers dictate that “live” experimentation must be approached only when there is an extremely minimal likelihood of negative interference with the current operations. The introduction of variations in the computer interfaces used in EOC’s would not only have defied this restriction, but would have been a prohibitively complicated process for an experiment. Furthermore, implementing a real-time situational awareness assessment would not have been possible at all in this context. It was therefore necessary to construct a system which would afford an approximate simulation of the EOC’s
operations, while also allowing the necessary control and collection of data necessary for experimentation.

The development of a suitable simulation and experimentation system for the EOC environment requires the implementation of functionality not found in other systems. Specifically, the abilities to deliver timed audio messages to a participant and then record their reaction times, and to adhere to the guidelines of the Situation Awareness Global Assessment Technique (SAGAT), were novel enough to spur the construction of a new set of tools. The specification of this simulation and experimentation system includes the following points:

- Emergency events, and the stages of response to a set of events, do not occur synchronously or at fixed intervals. An accurate simulation of events outside the EOC would produce a sequence of messages into the EOC which would appear very disjointed at small scales, but could be resolved into a broader situational context at larger scales. (e.g.: Imagine watching several movies simultaneously by breaking them into individual scenes and watching one scene from each movie in the set, and then cycling back to watch the next scene from each movie, and so on. All of the scenes will retain their order in their movies. Now allow that the movies do not all start at the same time, and that your viewing may be in blocks of one or several scenes from each movie before moving to the next.)
• The timing of the event messages would have to be controlled to follow a specified profile, yet would have to retain some randomness to preclude subjects’ abilities to foresee patterns in the messages.

• The breadth of possible event types, locations, resources, etc. must be controlled so that each simulation step can be analyzed and documented. As participants’ inputs are to be measured against the simulated conditions, and those inputs can come at any time, the fidelity of the measurement parameters is critical to an effective experiment system.

• The ability to pause a subject’s session, clear their display, request several points of input, and then resume their session from where it as suspended is necessary for a proper situation awareness assessment according to the SAGAT guidelines.

Beyond the requirements of the system which were listed above, there were implementation considerations for maximizing its data collection capability. This approach was inspired in part by the work of Luis von Ahn at Carnegie-Mellon University, who cast the data collection system for his doctoral research as an online game and produced a large volume of data for analysis. (von Ahn, 2007)(von Ahn, 2006)(von Ahn & Dabbnish, 2008) Though the domain selected for this research may not lend itself to the whimsical fun provided by his experimental tools, the fundamental building blocks are consistent. Additional design considerations for maximizing data collection included:
• Participation should not require a subject to visit a specialized facility, but rather should make use of commonly accessible technologies and require little if any additional control of the surrounding environment.

• The experimental apparatus should be highly portable, allowing the investigator to easily take all required components to locations where potential participants congregate, and if at all possible, eliminate the need for the investigator to be co-located with the participants.

• The experiment process should be minimally intrusive on the participants’ time and not require any special preparation or training before data collection can begin.

• Participation should be made to feel like playing a game as much as possible.

When considered in combination, the idea of constructing the data collection system as a web-based application came to mind. A web-based system is not confined to any specific location, and thus may be considered to be portable. However, there are several challenges to be addressed in order to produce a viable system meeting all of the requirements. Most significantly, controlling the timing of message delivery and maintaining the accuracy of time-to-respond metrics would have to be assured despite the variation in network communications latency between the web server and the remote clients.
Apparatus Design – General

Within a simulation, various emergency response resources (police, fire, and medical) based within each neighborhood of a city, are assigned and respond to a variety of incidents. From assignment through task completion, each resource is tracked in a “current status” database so that a complete situational picture can be assembled for any given time. As resource status updates are received, participants must interpret the messages and make appropriate entries via one of three randomly-assigned user-interface designs. Over the course of each session, the message arrival rates are varied from a slow period of approximately one message every ten seconds, to a fast period of approximately one message every four seconds. All participants would have to work through both the slow and fast periods through the course of their session. With each database update by the participants, status displays for each of the city sections, numbers of each type of incident, and the resource allocations are also updated. Participants are evaluated on the accuracy and timeliness of their data entries. Additionally, at a randomly selected point during the fast period of each participant’s session, the simulation freezes and a new form requesting answers to questions designed to determine their current situational awareness is presented. The timing of the situational awareness assessment is such that sufficient situational complexity has had a chance to develop, with an average of six or seven concurrent incidents, each with an average of two responding resources. Participants’ responses to the situational awareness assessment are evaluated against the simulation database’s running environmental model.
The experimental controls modified the realism of the domain simulation by regulating the pace of message arrivals, and by requiring multiple incidents to be initiated in an artificially accelerated pattern so as to assure a sufficiently rich situational model. The pace of message arrivals is controlled to provide a slow period which then speeds up and sustains a fast message arrival rate. The total time of the simulation, including the situational awareness assessment, is fifteen to twenty minutes.

The situational awareness scores are compared across the three interface variants; and accuracy and timeliness metrics are compared across the two message speed periods, as well as the three interface variants. Covariates to these analyses included gender, amount of time spent with computers and video games each day, and a basic measure of cognitive style (i.e.: left- or right- brain dominance), all of which were collected in a web-based pre-participation questionnaire.

**Experiment Design – Detailed**

**Specific Research Questions to be Addressed by Experiment**

1. Which of three human-computer interface variants better support users’ abilities to interpret and record environmental activity described by audio messages?

2. Which of three human-computer interface variants is better able to sustain situational awareness as environmental complexity increases?
Simulation System and Controlled Parameter Generation

**Overview**

A simulation was developed to produce a controlled but realistic sequence of environmental changes to be described to participants as audio messages. The tool used for building the simulation was Microsoft’s Excel spreadsheet program. Excel was selected for its ease of building and integrating the separate elements of the model, ability to quickly render graphical representations of simulation parameters and results, and the ability to easily export data into the experiment’s database.

The simulated environment is a generic geography divided into six sections or neighborhoods. Each section (neighborhood) of the city has a specific number of police, fire, and ambulance resources based within its area. The precise numbers of the individual types of resources varied among the neighborhoods, adding some realistic heterogeneity in resource distribution. Within the simulated environment, incidents of various types occur and spawn a series of subsequent events over a period of time. The incident type determines the resource requirements, and each assigned resource follows a typical pattern of status changes through their simulated responses. Each change of each resource assigned to each incident provides the sequence of events announced to the participants.

**Simulated Environment Detail**

Seven simple response scenarios provide the need for every combination of resources. (See Table 3 below for the breakdown of incident types and their resource requirements.) The
likelihood of each incident type occurring is controlled within the simulation, favoring the types which require multiple resources, and therefore produce more reportable events.

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Police</th>
<th>Fire</th>
<th>Ambulance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car Accident</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Chemical Spill</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Fight</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Robbery</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Fire</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Cat in a tree</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Medical</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Table 3 - Simulated incident types and resource demands

For each simulated incident, appropriate resources are assigned and follow a sequence of response steps. Each assigned resource will follow the sequence of:

1. Being dispatched to a specific incident.
2. Acknowledging the dispatch and traveling to the location of the incident.
3. Arriving at the scene and rendering assistance.
4. Becoming available for other incidents and returning to base.
5. Arriving back at base.

The timing of each stage of the sequence is based upon an analysis of emergency medical services response records provided by the Pennsylvania State University’s Office of Emergency Medical Services, following an analysis similar to that of (Zhu et al., 1992). This is designed to arrive at a realistic sequence of status change reports. The timing of the delivery of those status change reports is a controlled variable of the experiment. A sample of the script
created by the simulation is shown in Table 4 below. Time is expressed as seconds elapsed from the beginning of the simulation run.

<table>
<thead>
<tr>
<th>Time (seconds from start of simulation)</th>
<th>Message Text</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>There is a new fire incident in the Springfield region.</td>
</tr>
<tr>
<td>22</td>
<td>Fire engine number eight has been dispatched to the fire in Springfield.</td>
</tr>
<tr>
<td>31</td>
<td>Ambulance number seven has been dispatched to the fire in Springfield.</td>
</tr>
<tr>
<td>42</td>
<td>Medical unit number seven is enroute.</td>
</tr>
<tr>
<td>53</td>
<td>Fire truck number eight is enroute.</td>
</tr>
<tr>
<td>62</td>
<td>There is a new robbery incident in the Clinton region.</td>
</tr>
<tr>
<td>71</td>
<td>Police unit number eighteen has been dispatched to the robbery in Clinton.</td>
</tr>
<tr>
<td>80</td>
<td>Police car number eighteen is enroute.</td>
</tr>
<tr>
<td>91</td>
<td>Medical unit number seven is on scene.</td>
</tr>
<tr>
<td>102</td>
<td>There is a new spill incident in the Clinton neighborhood.</td>
</tr>
<tr>
<td>112</td>
<td>Fire unit number nine has been dispatched to the spill in Clinton.</td>
</tr>
<tr>
<td>121</td>
<td>Police car number nineteen has been dispatched to the spill in Clinton.</td>
</tr>
<tr>
<td>131</td>
<td>Police unit number nineteen is enroute.</td>
</tr>
<tr>
<td>142</td>
<td>Police car number eighteen is on scene.</td>
</tr>
<tr>
<td>153</td>
<td>Fire engine number eight is on scene.</td>
</tr>
<tr>
<td>163</td>
<td>Fire unit number nine is enroute.</td>
</tr>
<tr>
<td>173</td>
<td>There is a new accident incident in the Franklin area.</td>
</tr>
<tr>
<td>183</td>
<td>Police car number one has been dispatched to the accident in Franklin.</td>
</tr>
<tr>
<td>193</td>
<td>Medical unit number one has been dispatched to the accident in Franklin.</td>
</tr>
<tr>
<td>204</td>
<td>Fire unit number two has been dispatched to the accident in Franklin.</td>
</tr>
</tbody>
</table>

The timings of the messages are controlled by the simulation to meet the requirements of the experiment. At the beginning of a each participant’s session, the message arrival rate was in a “slow” state. This is set to an average of one message every ten seconds. The first forty percent of messages will sustain the “slow” delivery rate. The middle 20% of messages will constitute an acceleration period, where the message arrival rate will increase to the final “fast” rate. The final forty percent of messages will arrive at a “fast” rate, at an average of one
message every four seconds. The precise time between messages will vary normally around the calculated averages, with reasonable minimum and maximum values imposed. Please refer to Figure 17 below for an illustration of the timing changes through a single interface-use session.

Figure 17 - message arrival timing (delay, measured in seconds) over the time of single interface-use session, including a trend-line

**Audio Message Generation**

The simulation system which generates the message scripts also produces a series of commands which direct the creation of audio files containing the spoken versions of the messages. These command strings are processed by a Linux-based system which includes an installation of the open-source Festival text-to-speech (TTS) rendering engine (http://www.cstr.ed.ac.uk/projects/festival). A single voice was selected to be used for all messages within the simulation. The text of each message of each script was passed through the TTS engine and converted into a pre-defined and uniquely-named MP3 file. The name of each audio file was included in the database with its corresponding message data.
Data Collection System

Overview

The challenge of constructing a data collection system for this experiment is in the mixture of technologies which are needed to meet all of the design requirements. Database-driven interactive web applications have been in existence for nearly as long as the web itself. The methods of building such systems have been diversified as they have been mainstreamed, and there now exists several well supported options. The choice of one development language over another is often as much a personal decision by the developer as it is determined by the operational requirements.

A database driven web-based application was developed as the data collection vehicle for this experiment. The software was composed using the PHP and JavaScript programming languages, and interacted heavily with a MySQL database server. Some elements of the implementation incorporated asynchronous javascript and XML (AJAX) routines. An individual’s path through the various data collection scripts used in the process was controlled to allow forward-only progress. Figure 18, below, illustrates the sequence of screens through which each participant worked.
At the beginning of a session, each participant was automatically assigned a unique session identification number, which served as the primary key in a database used to record the participants’ performances. Demographic data was collected for each participant. At the conclusion of the session, participants were given the option to have their total “scores” recorded along with an e-mail address as part of a prize drawing to promote participation. The e-mail addresses are not tied to specific session ID’s, and therefore cannot be connected to demographics or performance measure details.

Potential subjects began by entering a website through a page containing a very general description of the experiment. By clicking on a button, subjects were directed to the Penn State Institutional Review Board (IRB) required and approved statement. (The complete set of IRB documentation is included in Appendix E – Institutional Review Board Documentation.)
Only by clicking on a button labeled “I agree” at the bottom of the statement, could a subject enter the data collection area of the application. As a first step in data collection, participants were asked to answer a set of demographic questions, including a subset designed to assess cognitive style (see below for more detail on this.) The script which posted the demographic information input form also assigned a unique experiment session identification number and selected a script and a user interface assignment for the experiment session. Once the demographic information had been recorded, a participant was referred to their assigned user interface page. Audio messages began to be played after a few seconds, and participants were expected to record their interpretations of the audio messages using the interface form. The audio messages sustained a slow rate (about 1 message every 10 seconds) for a time, and then accelerated and sustained a fast rate (about 1 message every 4 seconds) for a time. At a randomly-selected point during the “fast” phase of the experiment session – after sufficient situational complexity has built up – participants’ interface screens were blanked and they were presented with a form requesting responses designed to measure their situational awareness. Once a participant had submitted their responses, the assigned interface screen was restored, and the simulation was resumed. When the simulation had completed, each participant was given the option of entering their e-mail address into a set of drawings.

8 Script selection was made from a flat distribution of five equivalent script sequences. Interface selection was initially from a flat distribution over the three experimental interface variants, and later from a weighted distribution of the three variants to ensure statistically comparable sample sizes.
Demographic Data & Exclusionary Criteria

Once a participant has agreed to the provisions of the IRB statement, as indicated by their clicking on the “I Agree” button, they are directed to a demographic data collection form. Participants are asked to report:

- Gender
- Age category: 18-24, 25-34, 35-44, 44+
- If they have any uncorrected problems with their hearing.
- If they have any uncorrected problems with their sight.
- If they have any problems with the controlled use of their hands and arm which may affect their ability to use a computer mouse.
- If they have any prior work experience in 9-1-1 or other command-and-control facilities.
- The average number of hours they spend each day working on a computer.
- The average number of hours they spend each day playing video games.
- Their academic major, semester standing, and grade-point average.

Problems with hearing, vision, or arm/hand mobility, as well as any experience in command and control were deemed to be exclusionary criteria for this study. Participants who indicated any of these conditions were permitted to complete the experiment and be included in the drawings, but the data associated with their participation was not included in any analysis.
**Cognitive Style Assessment**

Within the demographic data collection worksheet is a section relating to the assessment of the subjects’ cognitive style. After reviewing several tools designed for this type of assessment, Crane’s Alert Scale of Cognitive Style (Crane, 1989) was selected as the most appropriate for implementation in this study. The assessment consists of twenty-one either-or questions, with the values of zero and one corresponding to the options of each question. The order of the option values is varied through the set of questions. The sum of the values of selected answers can range from zero to twenty-one, indicating a position on a left-brain (lower sums) to right-brain (higher sums) integer scale. The text of the questions and the original instructions for calculating a score are listed in Appendix D – Crane’s alert scale of cognitive style.

Under the rules governing the use of human subjects at Penn State, for the cognitive assessment to be included in the demographics section of the data collection tools, the option of refusing to answer any questions had to be allowed. In order to accommodate this constraint, the value of each question was changed to be negative one, positive one, or zero, with zero indicating no response. As a result of this change, scores could range from -21 to +21. Negative numbers indicate left brain dominance while positive numbers indicate right brain dominance.
**Timing and Accuracy**

Participants were provided with headphones so that the audio messages generated by the system would dominate their audio environment. As each simulation ran, participants had to interpret and record the environmental effects described by audio messages via one of three randomly-assigned interface variants. See Figure 19, Figure 20, and Figure 21, below for images of the interfaces tested. The timing and accuracy of their submissions were two of the three independent variables of interest.

The timing of audio message delivery was controlled by the system and the timing of each database submission was captured. The timing measurements were taken on the client side of the application, avoiding network latency which could have falsely inflated some values. The timing was measured to an accuracy of one second. The measurement of announcement-to-data-entry timing was a straightforward subtraction operation of the time a database entry was made and the time the corresponding announcement was delivered. Only entries which completely matched announcements made in the thirty seconds prior to submission were counted for timing analysis. In cases where duplicate entries were made, only the more proximate entry was used for analysis.

Accuracy was measured in two ways in order to capture two error types: (1) number of errant entries (i.e.: submissions which could not be correlated with recent audio message announcements), and (2) number of omissions (i.e.: audio message announcements which could not be matched with subsequent entries.) The two error types were treated as distinct
through the analysis process, though they surely overlap (e.g.: an announcement could not be matched to an entry because the entry was flawed). The distinct analyses provide the reader with the option of selecting either type as being more severe than the other.

Situational Awareness

Situational awareness could meaningfully be tested only after sufficient situational complexity had built up. A gauge of situation complexity was defined to be the product of the
number of concurrent incidents and the message arrival rate. This definition was implemented in an output function within the simulation system. This provided a continuous relative measure of situational complexity through each simulation session. A graph illustrating situational complexity through a session is shown in Figure 22, below. When compared to Figure 17, it can be seen that situational complexity is roughly a delayed inverse function of the time between messages. Because of the delayed effects of the increase in message arrival rate, situational awareness was assessed only in the final third of the simulation.

Figure 22 – Relative situational complexity through a simulated session.

Situational awareness was evaluated in accordance with the situational awareness global assessment technique (SAGAT). (Endsley, 1988) At a random time during the test period, a SAGAT interruption froze the simulation and cleared the participant’s display. The participant was then asked a set of questions designed to assess their situational awareness. (e.g.: Which area has the most police working in it right now? Which area has the fewest number of active incidents right now?)
Figure 23, below shows the SAGAT data collection form. To the extent possible within the medium, the format of the SAGAT collection form was matched to the running data displays. The participants’ answers were recorded, and later compared to the simulation system’s actual status at the time of the interruption. Once the SAGAT questions had been submitted, the participant’s display was restored and the simulation continued from its previous point.
Participant Selection

Participants were recruited from the undergraduate population of Penn State IST students at the University Park and DuBois campuses. Recruitment occurred via live presentations facilitated by the instructors of several courses. Participation was stressed to be voluntary, but was encouraged by offering inclusion in a set of random drawings for various prizes at the conclusion of the data collection period. Performance was encouraged by offering inclusion in separate prize drawings among those scoring in the top quarter of participants utilizing each type of interface.
Participants’ data was disqualified for inclusion in the study if the participant indicated they have a condition that may affect their physical ability to utilize the user interfaces (e.g.: hearing problems, color-blindness, motor control problems, etc.), or has any prior experience in command-and-control operations. In cases where a participant’s data were disqualified for inclusion, the participant was still eligible for the rewards drawing, if they so chose.

Data Analysis Plan

Participants were randomly assigned one of three interface variants, and operated it at a slow pace for several minutes, and then at a fast pace for several minutes. These controlled variables describe a 2x3 matrix of combinations shown below in Table 5.

<table>
<thead>
<tr>
<th>EXPERIMENTAL CONDITIONS</th>
<th>Enhanced text interface</th>
<th>Graphical Interface</th>
<th>Graphical Interface supplemented with voice recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SLOW message arrival rate</td>
<td>Condition 1</td>
<td>Condition 2</td>
<td>Condition 3</td>
</tr>
<tr>
<td>FAST message arrival rate</td>
<td>Condition 4</td>
<td>Condition 5</td>
<td>Condition 6</td>
</tr>
</tbody>
</table>

Table 5 - conditions examined

For each condition, participants produced measures of speed and accuracy resulting in a 2x3 matrix of data for analysis. Furthermore, participants produced measures of two levels of situation awareness across the three interfaces types. The data were analyzed with an iterative process employing SQL and Microsoft Access to retrieve, clean, and format data from the database, Microsoft Excel for further data refinement and visualization, and SAS for statistical
analysis. The analyses ran through simple t-tests to verify the parameters chosen for the two message arrival rates, tabulated the counts of response variables and covariates to describe the collective subject demographics, and the progresses to a series of ANOVA’s. Within each ANOVA, covariates from the collected demographics were included for analysis and type-III (current treatment entering last) sum-of-square tables were produced to evaluate covariate significance. The ANOVA’s were primarily composed as within-subjects models, which were then supplemented by between-subjects analyses were appropriate, and in the analysis of accuracy measures, a mixed model was used. To supplement the ANOVA tables, means and 95% confidence intervals were calculated and used to produce graphical representations of the analyses. The set of statistical comparisons undertaken in the analyses is illustrated in Figure 24, below. In this figure, each colored bar represents a statistical analysis connecting the subsets of the collected data to be compared.
## Experiment Implementation

In April and May, 2009, undergraduate students in Information Sciences and Technology courses at Penn State’s University Park and DuBois campuses were recruited to participate in the experiment. 137 sessions were recorded, of which 112 met all inclusion criteria. In exchange for their participation, participants were invited to be included in a drawing for a $25

<table>
<thead>
<tr>
<th>Metric</th>
<th>Basic text-only</th>
<th>Graphically Enhanced Interface</th>
<th>Graphically Enhanced Interface - supplemented with voice recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPEED during slow message arrival rate</td>
<td><img src="image1" alt="Graph" /></td>
<td><img src="image2" alt="Graph" /></td>
<td><img src="image3" alt="Graph" /></td>
</tr>
<tr>
<td>SPEED during fast message arrival rate</td>
<td><img src="image4" alt="Graph" /></td>
<td><img src="image5" alt="Graph" /></td>
<td><img src="image6" alt="Graph" /></td>
</tr>
<tr>
<td>ACCURACY during slow message arrival rate</td>
<td><img src="image7" alt="Graph" /></td>
<td><img src="image8" alt="Graph" /></td>
<td><img src="image9" alt="Graph" /></td>
</tr>
<tr>
<td>ACCURACY during fast message arrival rate</td>
<td><img src="image10" alt="Graph" /></td>
<td><img src="image11" alt="Graph" /></td>
<td><img src="image12" alt="Graph" /></td>
</tr>
<tr>
<td>SITUATION AWARENESS – Level 1</td>
<td><img src="image13" alt="Graph" /></td>
<td><img src="image14" alt="Graph" /></td>
<td><img src="image15" alt="Graph" /></td>
</tr>
<tr>
<td>SITUATION AWARENESS – Level 2</td>
<td><img src="image16" alt="Graph" /></td>
<td><img src="image17" alt="Graph" /></td>
<td><img src="image18" alt="Graph" /></td>
</tr>
</tbody>
</table>

Figure 24 - Illustration of statistical comparisons made in the analysis
gift certificate. To provide additional incentive for performance, participants who achieved higher than average scores were entered into a second drawing.\footnote{There were participation and performance drawings for each of the three interface variants used in the experiment.}
RESULTS

Overview

Subjects were recruited from current College of Information Sciences and Technology students at Penn State’s University Park and DuBois Campuses. In all, 137 sessions were recorded. Twenty-five of those were disqualified from analysis due to incompleteness or meeting explicit disqualification criteria. In total 112 validated sessions were used for analysis. These 112 sessions generated 6664 database entry events which could be used for timing and accuracy analysis, and 1662 situation awareness data points. These data were broken down to describe various demographic aspects of the test group, and then analyzed to evaluate the statistical differences in timing, accuracy, and situation awareness across three interface variants (between subjects), and two speed modes (within subjects). Unless otherwise noted, statistical significance was considered to be at the 0.05 level. In ANOVA analyses where covariance was measured, the type-III (current factor last) sum-of-squares values are reported.

Demographics

The following demographic descriptors are represented graphically below in Figure 25, Figure 26, and Figure 27. Of the 112 valid data collection sessions:

- 82 (73%) were completed by male participants and 30 (27%) were completed by female participants.
- 90 (80%) of the valid participants were between the ages of 18 and 24, with 10 (9%) within the ages of 25-34, 8 (7%) within the ages of 35-44, and 4 (4%) being over 44.
• 81 (72%) were majoring in Information Sciences and Technology, 11 (10%) were majoring in Business, 1 (1%) was majoring in Communications, 5 (4%) were majoring in Engineering, and 12 (11%) selected “other” as their major. 2 participants (2%) did not disclose their major.
Cognitive style assessments were completed in full by all 112 validated participants. The assessments are based on Crane’s Alert Scale of Cognitive Style (Crane, 1989), which results in each individual achieving a score from zero to twenty-one. Lower values indicate left-brain dominance and higher values indicate right-brain dominance. Values in the range of nine to thirteen indicate dominance by neither side. Employing the labels and score ranges provided by Crane:

- 3 (3%) participant showed a strong left-brain dominance
- 30 (27%) participants showed a moderate left-brain dominance
- 51 (45%) participants showed no dominance by either side
- 22 (20%) showed a moderate right-brain dominance
- 6 (5%) showed a strong right-brain dominance

The distribution of cognitive style scores is shown below, in Figure 28.
The cognitive style assessment scores were compared across some of the other demographic data. In particular gender and academic major categories were compared via cognitive style. The results are shown in Figure 29, below. There was not sufficient data representing the variety of academic majors to determine any significant differences in their average cognitive style scores. However, the difference in average cognitive style score between genders was shown to be statistically significant ($p=0.0287$) using a simple t-test. 

---

10 The scale of this graph originates from the modification to the Alert Scale of Cognitive Style required for implementation in this experiment’s design. The modification shifts the pre-defined mid-point to zero, with left-brain-ness indicated by negative values and right-brain-ness indicated by positive values.
Timing Analysis

Each of the 112 accepted participants received 72 audio messages, which would optimally result in 8064 valid database entries. There was a total of 6664 recorded entries (a.k.a. “reports”), 5339 of which (80.1%) could be matched to audio message deliveries (a.k.a. “announcements”) within the 30 seconds prior to the report entry time. These numbers also indicate an overall 17.4% dropped message rate, and a 33.8% overall not-recorded (dropped or

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11 This and subsequent comparative graphs display, for each category, an average value surrounded by a 95% confidence interval bar.
errantly entered) rate. The gross timing analysis\textsuperscript{12} illustrated below in Figure 30 and Figure 31 show the average time, in seconds, measured from audio message delivery to submission of corresponding database entry, surrounded by a 95% confidence interval.

A t-test was run to show that the average difference in timing between the fast and slow message delivery periods was significant (p<0.0001). This is verification that the message timing designed into the experiment was proper. Had a statistically significant difference not

\textsuperscript{12} The term “gross timing” refers to each database entry even being treated individually, rather than being aggregated by session membership as is done in subsequent calculations.
been found, the timing would have been adjusted. Beyond validating the experiment design parameters, this analysis step was also used to look for indications of significant covariates. Cognitive Style (p=0.0068) and Gender (p=0.0295) were found to be significant individual covariates. Also, several significant covariate interactions were found, for the most part involving the time spent working on computers or playing video games.

With the experiment parameter verification provided by the gross timing analysis, a subsequent mixed-model analysis of variance of the session-aggregated values was undertaken. Aggregation by session and speed mode was used to remove the effects of variation in the numbers of reports made by individual participants. Table 6, below, shows the basic descriptive statistics of the session-aggregated report timings. Figure 32 shows the mean timing and 95% confidence ranges across the six experimental conditions.

<table>
<thead>
<tr>
<th>Experimental condition</th>
<th>Interface #1</th>
<th>Interface #2</th>
<th>Interface #3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>at slow</td>
<td>at slow</td>
<td>at slow</td>
</tr>
<tr>
<td></td>
<td>message arrival rate</td>
<td>message arrival rate</td>
<td>message arrival rate</td>
</tr>
<tr>
<td>n:</td>
<td>28</td>
<td>36</td>
<td>42</td>
</tr>
<tr>
<td>s.d.:</td>
<td>1.47</td>
<td>1.94</td>
<td>1.63</td>
</tr>
<tr>
<td>mean:</td>
<td>6.64</td>
<td>6.40</td>
<td>6.20</td>
</tr>
</tbody>
</table>

Table 6 - session aggregated response timing (in seconds) across experiment conditions
The ANOVA shows that slow-period response times are statistically different across interfaces ($F(42,105)=1.58; p=0.0494$), but fast-period response times are not ($F(41,92)=0.92; p=0.6076$). The significant factors contributing to the timing variations are interactions of cognitive style with time spent playing video games ($F(1,105)=4.22; p=0.0441$), and with video game time and time spent working with computers ($F(1,105)=5.99; p=0.0172$). The effect of the interaction of cognitive style and interface assignment is on the margin ($F(2,105)=3.12; p=0.0511$). No independent factor was found to be significant.
**Accuracy**

Accuracy can be measured several different ways. These interval graphs in Figure 33 and Figure 34 show the number of accurate and inaccurate submissions as a percentage of the total number of audio messages delivered to the participants. As these data are broken down by interface assignment, these graphs are based on a between-subjects comparison. Neither measure of accuracy here revealed a significant difference between interfaces.

The remaining percentages for each interface represent the unreported messages.

Figure 35, below, illustrates the combined mean percentages of valid, invalid, and missing
reports compared to the total number of audio messages delivered to participants, broken down by interface type.

For the next analysis, the accuracy metric was changed to represent only the number of “active errors”: submitted entries which could not be correllated with previous outgoing audio messages. This measure excludes errors of omission, which might be explained by the pace of message arrival. The results are shown in Table 7 and Figure 36, below.

It is interesting that the percentage of invalid reports during the “slow” period was minimized (though not significantly so) with the third interface variant, while in the “fast” period, errors were minimized (this time significantly) with the second interface variant. The difference between these interfaces is the addition of a text transcription of the audio.
messages in interface three. A possible interpretation is that during the slow period, participants were able to verify the messages using both the audio and the text, while at the fast rate of message arrival they struggled to use both, which backfired and caused more errors.

<table>
<thead>
<tr>
<th>experimental condition: interface</th>
<th>interface</th>
<th>interface</th>
<th>interface</th>
<th>interface</th>
<th>interface</th>
<th>interface</th>
</tr>
</thead>
<tbody>
<tr>
<td>message arrival rate</td>
<td>#1 at slow message arrival rate</td>
<td>#2 at slow message arrival rate</td>
<td>#3 at slow message arrival rate</td>
<td>#1 at fast message arrival rate</td>
<td>#2 at fast message arrival rate</td>
<td>#3 at fast message arrival rate</td>
</tr>
<tr>
<td>n:</td>
<td>30</td>
<td>40</td>
<td>42</td>
<td>27</td>
<td>31</td>
<td>41</td>
</tr>
<tr>
<td>s.d.:</td>
<td>0.2344</td>
<td>0.2836</td>
<td>0.1748</td>
<td>0.2400</td>
<td>0.0904</td>
<td>0.2420</td>
</tr>
<tr>
<td>mean:</td>
<td>0.1927</td>
<td>0.1915</td>
<td>0.1189</td>
<td>0.2541</td>
<td>0.1719</td>
<td>0.2357</td>
</tr>
</tbody>
</table>

Table 7 – mean percentage of reports (aggregated by session) which were invalid, broken down by experiment group

The differences between interfaces was significant at the fast message arrival rate.
The error rates across the three interfaces are significantly different only at the fast rate of message arrival ($F(5,98)=3.62; p=0.0049$). The only individually significant covariate to this is gender ($F(1,98)=14.87; p=0.0002$). If all possible interactions are included, the significance level for interface increases to $p=0.0005$ ($F(29,98)=2.65$) with no significant (SS type-3) covariates. The sample was not sufficient for SS type-3 calculations for some of the proposed covariates. However, SS type-1 covariate analysis shows gender as highly significant ($F(1,98)=18.65; p<0.0001$) after cognitive style, computer time per day, video game time per day, and all of their interactions were included in the model. With gender playing a significant role in the model, the data regarding the fast-period error rates was broken down further, differentiating between the male and female performances with each interface. The results are illustrated below in Figure 37.
The graph shows that both men and women performed better with the graphical interface than with the text-only interface; however the difference was much more dramatic in the male group. The difference between the graphical interface and graphical interface with message transcripts shows a near doubling of the mean error rate in the female samples, while only a slight increase in the mean error rate is evident in the male samples.

As a last way to look at the measurement of accuracy, the gross error rates across the six experimental conditions were calculated and are shown in Figure 38 and Table 8, below.
Figure 38 - Gross active error rates, broken down by experiment condition

Table 8 - Gross error rates, broken down by experiment group

<table>
<thead>
<tr>
<th>Experimental condition:</th>
<th>interface #1 at slow message arrival rate</th>
<th>interface #2 at slow message arrival rate</th>
<th>interface #3 at slow message arrival rate</th>
<th>interface #1 at fast message arrival rate</th>
<th>interface #2 at fast message arrival rate</th>
<th>interface #3 at fast message arrival rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>n:</td>
<td>170</td>
<td>234</td>
<td>148</td>
<td>172</td>
<td>166</td>
<td>185</td>
</tr>
<tr>
<td>all:</td>
<td>973</td>
<td>1218</td>
<td>1242</td>
<td>847</td>
<td>1028</td>
<td>1106</td>
</tr>
<tr>
<td>pct:</td>
<td>17.47%</td>
<td>19.21%</td>
<td>11.92%</td>
<td>20.31%</td>
<td>16.15%</td>
<td>16.73%</td>
</tr>
<tr>
<td></td>
<td>Interface #1</td>
<td>Interface #2</td>
<td>Interface #3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------</td>
<td>--------------</td>
<td>--------------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Overall accurate reporting rate during fast and slow periods:</strong></td>
<td>82.1%</td>
<td>76.9%</td>
<td>80.0%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gross slow-period accurate reporting rate:</strong></td>
<td>89.2%</td>
<td>82.0%</td>
<td>86.8%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gross fast-period accurate reporting rate:</strong></td>
<td>75.0%</td>
<td>71.8%</td>
<td>73.1%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Difference:</strong></td>
<td>14.2%</td>
<td>10.2%</td>
<td>13.7%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 9 - Gross accurate reporting rates by interface assignment and message arrival speed

**Situation Awareness**

Situation awareness was assessed in accordance with the Situation Awareness Global Assessment Technique (SAGAT) guidelines. As participants were working through their simulations, their sessions were frozen at a random point in the latter half of their session (once sufficient situational complexity had built up), and their displays were replaced with a form asking for data demonstrating the participants’ understanding of the current situation. The format of the SAGAT data entry form was designed to mimic the format of the primary interface, but did not provide any feedback regarding the current conditions, and used numeric-only entry fields.

The SAGAT form’s fields requested data which could be used to assess level-1 (i.e.: perception of current situation) and level-2 (i.e.: comprehension of the current situation) situation awareness. Level-3 situation awareness (i.e.: projection of the situation into the near future) was not assessed because the simulation through which the participants worked
progressed independently of their inputs, and was based on discrete randomly timed events which were designed to be non-predictable.\textsuperscript{13}

Level-1 situation awareness accuracy rates were calculated across the three interface types and processed into the 95% confidence interval plots shown above. Figure 39 illustrates the absolute accuracy rate of responses: the number of responses which were precisely correct.

\textsuperscript{13} Although an intermediate stage of the simulation system produced a Poisson random event sequence, the finishing stages replaced the event timings with controlled normally randomized timings triggered by the previous event. This necessarily reduces the unpredictability of the event timings, but maintains the unpredictability of the event details which would be the basis for Level-3 situation awareness.
compared to the total number of responses. Figure 40 employees the SAGAT guideline of setting a tolerance for correct vs. incorrect responses.\textsuperscript{14}

The differences of the mean accuracy rates through the three interfaces are not statistically significant ($F(43,107)=1.54; p=0.0580$). However, because the level-1 SA assessment data was comprised completely of single-dimensional quantitative values, an evaluation of the magnitudes of the errors made by participants was possible. The analysis of the error magnitudes, illustrated in Figure 41, below, show that they differ significantly ($F(43,107)=3.73; p<0.0001$) across the interface types. The only significantly contributing covariates are gender ($F(1,107)=84.15; p<0.0001$) and interactions there with.

\textsuperscript{14} The tolerance used was +/- 1 of the actual measure (e.g.: number of incidents in a region, number of police incidents, etc.)
As was done with the accuracy analyses when gender appeared as a significantly contributing factor, the level-1 SA data was also broken down by gender as well as interface assignment. This treatment was applied to both the error rate data as well as the error magnitude data. The resulting 95% confidence intervals are shown in Figure 42 and Figure 43, respectively. These plots show the data broken down by gender and interface through the first six columns, and then just by gender in the final two columns.
In these charts, the data show that the male participants are, on average, more accurate in level-1 situation awareness scores than their female counterparts. Furthermore, as shown below in Figure 44, on average, the errors made by the males in the group were smaller than those made by the females. However, the ranges of the confidence intervals describing the female participants are too wide to yield any statistically significant findings. The widened confidence intervals are likely an artifact of the underrepresentation of females in the sample – 30 of 112, 27% overall.
The analysis of level-2 situation awareness across interface variants is illustrated below in Figure 45. The differences across the three interfaces were not significant, and the nature of the level-2 SA evaluation criteria does not permit the possibility of an analysis of error magnitudes as was done with the level-1 SA data.
As gender had been playing an important role in previous analyses, the level-2SA accuracy was also broken down by gender as well as by interface. The graphical results of this analysis are shown in Figure 46.
Summary

The time needed to enter message content was not significantly different across the interface variants at the “fast” rate of message arrival, but during the “slow” period, the interfaces with graphical enhancements supported significantly better performance (p=0.0494). The addition of a text transcript of the arriving messages also decreased the time it took to make entries, but this may be explained by the messages being available via the visual channel faster than they are through the audio channel. The time a participant spends playing video games or working on a computer each day combined with their cognitive style contributed significantly to improving their response times in the experiment.

Errors of omission were not significantly impacted by the selection of interface variant. However, the differences in error rates between interface variants were significant during the “fast” message arrival rate (p=0.0049). Interface number two, with graphical enhancements but no text transcription minimized the overall error rate, while interface number one and interface number three performed nearly equally. The major covariate factor was gender (p=0.0002). While men performed consistently between interfaces two and three, the differences between women’s performance across the interface variants was more dramatic. The discrepancy was greatest on interface number three, where the women had more than double the error rate of the men in the test group.
Level-1 situation awareness accuracies across the interfaces were not quite significant ($p=0.0580$), but the magnitudes of the errors were ($p<0.0001$) with gender being a strong covariate ($p<0.0001$). On average, women made bigger mistakes in their level-1 SA responses. Level-2 situation awareness accuracies were not significantly different across the interface variants.
CONCLUSIONS & DISCUSSION

Overview

This study was based on the activity observed in emergency operations centers (EOC’s), where times of extreme situational complexity are rare, but reflect extraordinary external circumstances. In a best case scenario, an EOC deals with a threat to property. Very often, though, the threats extend to include bodily harm and even life-and-death conditions. It is easy to see that when a number of these threatening events arise simultaneously, the value of appropriate and timely resource assignment rapidly increases.

In domains where atypical situational complexity is to be expected, the cost of implementing real-time situational feedback in an appropriate format for the users of information systems can easily outweigh the detrimental impacts of ill-informed resource allocation. The study shows that the data entry and feedback mechanisms do not have to be radical departures to have an effect. The alteration of a text-based display by adding color fields and some graphical status reporting resulted in better performance between groups of laypeople. If such minor differences can impact untrained individuals, more comprehensive testing with domain experts could lead to cognitive system designs which would be effective in real-life emergency conditions.

The analysis shows that slight differences in interface design can have significant effects on the accuracy, situational awareness, and even timeliness of users tasked with intermodal information handling. While under normal conditions, the effects may be inconsequential, but
when situational complexity increases, the improved performance may drastically affect outcomes.

There were 112 participant sessions included for analysis. Each participant completed a demographics survey, including a set of questions designed to assess “cognitive style.” Each participant then received 72 audio messages, beginning with 30 messages delivered at a rate of about one every ten seconds. The message delivery rate accelerated over 12 messages and held a rate of about one message every four seconds for 30 messages. Participants were expected to interpret the message contents and record their interpretations into one of three randomly-assigned user interfaces. At a random point during the fast message delivery period, the messages stopped, the participants’ screens were cleared, and participants were asked to complete a worksheet to assess their situational awareness. A total of 6664 reports were entered into the database by the participants, which is 82.6% of the total 8064 messages which were delivered. 5339 reports could be matched with messages, representing 66.2% of all delivered messages and 80.1% of all received reports.

There was a total of 3360 announcements delivered for each speed mode (112 sessions x 30 messages per period). The outstanding announcements took place during the acceleration period and were not classified into either the slow or fast groupings. The simplified text-only interface had the highest gross accurate reporting rate of 82.1%, which was maximized at 89.2% during the slow message arrival rate period. When the announcement rate increased, the accurate reporting rate for interface one fell to 75.0%. The third interface, which employed
a more graphical appearance as well as a text transcription of the audio messages, had similar
gross accurate reporting rates: 86.8% during the slow period dropping to 73.1% during the fast
period. Interface two had the smallest change between slow and fast periods: 82.0% to 71.8%.
However, it also had the lowest overall rate: 76.9%.

The impacts of interface variation and message arrival rate on report speed and accuracy

In a simple t-test used to verify the adequacy of the experiment’s timing parameters,
cognitive style (a measure of left or right –brain dominance) and gender were found to be
independently significant factors. The p-values of 0.0068 and 0.0295 respectively were derived
from Sum-of-Squares Type-III covariate analysis, which evaluates each factor after all other
factors, and in this case all other factor interactions as well, are considered. The implication of
these findings is that while gender and cognitive style may be correlated, the correlation is not
strong enough to eliminate either individual factor from the model determining response
speed.

An ANOVA shows that the aggregated fast-period response times are not significantly
different between the three interface versions. However, a statistically significant (p=0.0494)
difference was found in the aggregated slow-period response times across the three interface
variants. (Refer to Table 6 and Figure 32 for more detail.) The largest difference between the
mean response times was 0.44 seconds, which though adequate for statistical significance,
would have little practical meaning under a sustained average arrival rate of one message every
ten seconds. One observation of note is that the fastest average response time during the fast period of message arrival was just under five seconds. With the (controlled) average fast-period message rate of one message every four seconds, this means that more often than not, participants were submitting their interpretations of each message while the next message was being delivered.

The accuracy of the submitted reports can be evaluated under several different definitions. The relative values of false reports versus non-reports can vary widely from domain to domain, and may be subjective. The basic measurement of completeness: the categorized ratios of all reports to all announcements, is detailed above and is a fundamental, but incomplete, representation of accuracy. An overview of valid, invalid, and missing reports, based on total number of announcements and broken down by interface assignment, is shown in Figure 35 (on page 90).

The first set of metrics used to compare performance across the interface variants is the averaged valid/invalid/missing rates per participant session, including both slow and fast announcement arrival rates. This structure required between-subjects ANOVA, which determined that the differences between valid reporting rates across the three interfaces, as well as the differences between invalid reporting rates across the three interfaces, were not statistically significant.

The next analysis measured “active errors” which were defined to be data entries that could not be correlated to any of the audio announcements made in the thirty seconds prior to
the data entry event. Overall, these rogue entries constitute almost one-fifth of all of the reports received from participants. The distribution of active errors across the six experimental conditions (three interface variants at two distinct message arrival rates) is shown in Figure 36 on page 92. The analysis of errors made during the slow message arrival rate period shows a decrease from around 19% for the first two interface types, to about 12% for the third interface which included a text transcription of the audio message. However, the differences are not statistically significant. During the fast message arrival rate period, the difference in error rates among the three interfaces is significant ($F(5,98)=3.62; p=0.0049$) and minimized with interface two at 17%. Covariate analysis reveals gender to be the only individually significant factor ($F(1,98)=14.87; p=0.0002$). Allowing interactions to play into the model raises the significance of the interface variation ($F(29,98)=2.65; p=0.0005$), and gender remains as the sole significant covariant ($F(1,98)=18.65; p<0.0001$).\(^{15}\)

As a follow-on analysis, the fast-period error data were parsed by both gender and interface factors. The graphical comparison of the resulting values is shown in Figure 37 on page 93. For both the male and female groups, errors were minimized using the second interface variant: graphical, but without a text transcription of the audio message. Using the second interface type, males committed errors on an average of 14% of their reports while their female counterparts committed errors on an average of 22% of their messages. The

\(^{15}\) Due to the limited sample sizes for comparing error rates across interface assignment and gender, some of the sum-of-squares type-III calculations could not be performed. The given F and P values are derived from the sum-of-squares type-I calculations after cognitive style, hours of daily computer use, hours of daily video game play, and all of the interactions between those factors was already included.
difference in error rates between the second and third interface types is intriguing as it indicates a very slight increase for the male participants while the female participants doubled their error rate to 44%. However, the small sample sizes and wide distributions of the data from female participants preclude the establishment of statistical significance.

As an alternate way to analyze the accuracy of submitted reports, the gross report data (i.e.: not aggregated by participant) were used to produce a mean error rates for the six experimental conditions aggregated over all valid user submissions. The results are shown in Figure 38 and Table 8, on page 94. The data show that active errors were minimized at 12% of submissions during the slow message arrival period by participants using the graphical interface which included the text transcription. However when the message arrival rate sped up, the accuracy advantage of the text transcription component disappeared; the second and third interface variants were responsible for about the same percentage of errors. Interestingly, the second interface (graphical without text transcription) showed a decrease in the percentage of errant reports submitted as the message arrival rate accelerated. However, when these figures are normalized against the total number of messages delivered per experimental condition (30 messages were delivered to participants for each slow and each fast period), the advantage of accuracy is tempered by a decrease from 82% of announcements being accurately reported during the slow period to only 72% during the fast period – the lowest accurate report completion rate among the interfaces. These details are shown in Table 9 on page 95.
The impacts of interface variation on situational awareness

Situational awareness is broken into three levels by Endsley, who established the Situational Awareness Global Assessment Technique (SAGAT) guidelines used in this experiment. The first level of situational awareness (SA) is the knowledge of the raw facts of a situation. The second level is the understanding of the potential impacts implied by the elemental data. The third level of situational awareness is the extrapolation of significant elements of the situation into the near-term future. The design of this experiment accommodates the evaluation of SA at levels one and two. Level three SA could not be assessed for two main reasons: the participants were unfamiliar with the system on which they were being evaluated, and the requirement for a randomized distribution of event announcements eliminated any patterns which could have been used to make near-term predictions.

Level-1 SA was assessed by looking at both absolute differences between the simulation’s model and the feedback from participants, and then by employing the SAGAT guideline of establishing acceptable tolerances around the correct values to determine the accuracy of participant feedback. The results of these two evaluations are shown in Figure 39 and Figure 40 on page 96. The differences of accuracy rates between the three interfaces were not significant at the 95% level in either evaluation. However, the simplicity of the data used to evaluate level-1 SA (all metrics were positive integers) allowed for a follow-on analysis of the magnitudes of errors made by participants. The error magnitudes were found to be significantly different across the interface variants ($F(43,107)=3.73; p<0.0001$). The average error made by
participants using the third interface (graphical and including a text transcription of audio messages) was nearly double the average errors made by participants using the other interfaces at 0.631. Interface #1 errors were off by an average 0.278 and interface #2 errors were off by an average 0.319. Moreover, the distribution of errors was much wider by users of interface #3: a standard distribution of 1.773 compared to 0.644 and 0.703 for interfaces one and two, respectively. These means and 95% confidence intervals of the error magnitudes are shown in Figure 41 on page 97.

The covariate analysis again revealed gender to be an independently significant factor \( (F(1,107)=84.15; \ p<0.0001) \), as well as several other factors’ interactions with gender. As was done with the reporting accuracy data, the level-1 SA data were broken down by gender and by interface assignment for further analysis. The graphical outcomes from these evaluations are shown in Figure 42, Figure 43, and Figure 44, beginning on page 98. Across the board, male participants achieved higher accuracy rates. However, the widened confidence intervals among the female participants (most likely due to the smaller sample sizes) make statistical comparisons between genders from interface to interface inconclusive. In the level-1 SA accuracy measures aggregated across all interfaces, males outperformed the females by about 9.5% regardless of whether we look at the absolute or within-tolerances values. With the error magnitude data, women tended to overestimate values by 0.8, which is about 0.5 more than the men did. These errors are within the established error tolerance levels, and so would still be considered correct under the SAGAT guidelines. When the error magnitude data was broken
down further to differentiate by interface assignment as well as gender, one combination stands out. Women using interface three (graphical with a text transcription of the audio messages) tended to overestimate the values by just over 1. This combination also had the widest distribution of values among the categories, and had a standard distribution value of more than three times that of women using interface two with a similar sample size.\textsuperscript{16}

Level-2 SA accuracy measures were not significantly different across the three interface variants. In all three cases, level-2 SA was in the low-50% range. When the data were parsed by interface as well as gender, the differences in the accuracy measures between the categories still do not reach statistical significance, but an interesting pattern emerges. The women’s level-2 SA accuracy decreases though the interfaces while the men’s accuracy increases. This pattern, which is illustrated in Figure 46 on page 102, suggests that the interface elements which maximize men’s level-2 SA accuracy may minimize women’s level-2 SA accuracy. Also, it can be seen by comparing Figure 46 to Figure 44, that the interface with which women scored the lowest overall level-1 SA score was also responsible for the highest overall level-2 SA score, implying that despite a poor grasp of the situation’s details, they had a good understanding of the situational meanings. Unfortunately, with the exception of comparing the third interface across genders, all of these patterns regarding the level-2 SA measures are based on an insufficient sample to establish statistical significance. The difference in level-2 SA accuracy rates between the female and male users of interface #3 is more than double: 30.0% to 60.7%.

\textsuperscript{16} SA-level-1 errors by women using interface #2: n=13, s=0.8910. SA-level-1 errors by women using interface #3: n=12, s=2.9235.
respectively, and is significant with p=0.0238 (F(15,41)=2.41). A more vigorous investigation will have to be conducted to affirm or dispute these interesting but anecdotal patterns.

**Conclusions**

With the data that was collected in, it can be concluded that the slight visual interface variations used in this experiment did have an impact on the speed of inter-modal data transposition. The impact was only significant at the slow message arrival rate, and is probably not of practical importance in the domain of emergency response. The most likely reason for the improved response speed in that the graphical versions of the interface allowed participants to more easily locate the specific elements they were searching for by providing a very broad filtering signal in the form of a color-coded background coinciding with an easily interpretable icon. The additional improvement in speed between the users of interface two and interface three can be explained by the addition of the visual channel for data input. The text transcription of the audio message appeared at the same time as the audio message began playing. If the subjects were able to cognitively transpose the visible message more quickly than the audio message arrived, it would result in an improved data entry time. This might also account for the loss of the speed benefit when the message arrival rate accelerated: the visual attention needed in order to enter data forced the user of interface three to switch to receiving the message data more by the audio channel.

The impact on the accuracy of data entered by the various interfaces is both more profound and more relevant for inter-modal interface designs. Using the “active error” metrics
(submitted reports which could not be correlated to announcements) during the fast message arrival period, errors were minimized with interface two, which incorporated color-coded fields but did not show a text transcript of the audio messages. The third interface, which is exactly the same as the second except that it does incorporate a transcription element, had a significant increase in errors, from 17.2% to 23.6%. This suggests that the addition of a secondary data channel leads to an overtaxing of the users’ abilities to process the incoming data – it would be better for accuracy to select a single mode for data arrival.\textsuperscript{17} This contradicts the pattern that was present during the slow message arrival period, and what many would expect: that the secondary data channel would be used as a verification of the data and would lead to more accurate reporting. At the same time the message reporting time dropped (not significantly) by 0.21 seconds. The addition of the text transcript may have enabled a slightly faster transcription, but it definitely caused a loss of accuracy.

Level-1 situation awareness was assessed two ways. The traditional metric of the percentage of correct answers did not reveal any significant differences between interfaces. That is to say, we cannot determine that the interface selection had any impact on the number of correct SAGAT responses. The differences in the magnitudes of the errors were significant. The addition of the text transcription in interface three seems to be responsible for bigger errors, even if not more of them.

\textsuperscript{17} It is important to realize that the text transcriptions of the audio messages were intended to represent the output of a “perfect” speech-to-text translation system. The text transcription matched the audio message exactly (in fact, the text had been used to generate the audio), and appeared simultaneously with the audio delivery.
There was not enough variation in the level-2 situation awareness scores to conclude anything regarding the impact of the interface variations on those metrics. The accuracy percentage scores for all three interfaces were in the low-fifties (slightly lower for interface #3). This may be due to the participants’ attention being drawn to the immediate active tasks associated with data entry, and inexperience with situations requiring the development and maintenance of situational awareness.

The gender of the users was a significant factor in many of the findings of this experiment. Unfortunately, the distribution of gender across the interface types was not adequate to conclude that any one interface type was better or worse for men and women. The patterns that are present in the collected data do, however, reveal some interesting relationships worthy of further exploration. Foremost among these is the complementary relationships of the level-1 and level-2 situation awareness between men and women. It is important to keep in mind, however, that this experiment specifically excluded data produced by persons who reported any prior experience with similar systems. I believe it is likely that the gender-split results would resolve if some training and/or a period of acclimating to the interface was implemented.

**Recommendations arising from experimental findings**

In information systems where inter-modal interfaces must provide for fast and accurate data entry, design considerations must extend beyond basic functionality to include visual
cueing, including such elements as varying background colors to divide large displays and meaningful symbols to supplement written labels.

Situation assessment accuracy can also be affected by slight variations in the interface design. Though the results of this experiment do not conclusively show that the percentage of correct responses can be correlated with the interface design, it does show that the magnitude of errors can be affected. At a minimum, this finding should drive design considerations to include a comparative impact analysis of the number of errors versus the severity of errors.

In summary, the linkage between the reality of the external environment and the situational model held within the emergency operations center and used for decision support (refer back to Figure 10 on page 12) can be impacted by relatively simple changes in the interfaces used by the emergency telecommunicators.
FUTURE WORK

Overview

There are three main paths foreseen for the future development of this work: the refinement and continued development of the tools developed for the experiment, repeating the experiment with some changes to the fundamental parameters, and the extension of the experiment concept into other domains.

Refinement and packaging of the assessment tools

The tools developed for this experiment can be refined for general use and released as open source software. The tools fit for public dissemination are divided into two categories: the simulation which populates a database, and the web-based interactive system which uses the database. The overall contribution of these tools is a tested framework for measuring a wide variety of parameters within an inter-modal (audio-to-manually-submitted) information system.

The simulation system, on its own, can be used as a platform for quickly constructing accurate simulations of sequentially compounded randomly timed events. The simulation is constructed within a Microsoft Excel workbook, which is familiar to many people; modifying the simulation to work for other domains should not be difficult. Furthermore, the simulation system was specifically constructed to provide situational awareness parameters at each step of the simulation run. It would be possible to utilize this data in a real-time individualized user-feedback mechanism as a method of training or testing potential practitioners.
The web-based data collection system is based on the common PHP and JavaScript web-application programming languages, and utilizes a MySQL database server as a backend. These technologies represent some of the most common open source software being used today. The user interface forms and the data recording functions could be modularized to maximize the flexibility of the framework.

**Variations on the experimental parameters**

This experiment was very limited in its scope in several regards, and could easily be modified and/or expanded to study alternate interface designs, populations, or performance metrics.

The three interfaces selected as controlled variables were only subtly different in their appearance and behaviors. The natural extension of this is the utilization of a wider variety of interfaces to test further the elements which affect performance. A more ambitious variation would allow some users to arrange their own interfaces and test the user-arranged versions against other static layouts.

The population from which participants were recruited may not provide an accurate representation of the users in the actual domain being simulated. It would be interesting to run the experiment with a set of emergency telecommunicators as the subjects to see how their results compare to those of the laypeople. However, this approach may make it difficult to reach any significant conclusions due to the small number of people in this niche profession.
Alternatively, participants could be run through a “practice session” which includes the SAGAT assessment to prepare them for the experience.

The other controlled variable in the experiment was the timing of audio message delivery. The simulation system produced a timed script based on normal probability distributions extracted from prior investigation. The result is a script which varies between long periods of quiet and bursts of concurrent messages – true to the reality of emergency communications centers. The finishing stage of script preparation controls the timing between messages, and thus smooths the message delivery times. This eases the statistical comparison of “slow” and “fast” periods, and facilitates uniform situational complexity across subjects, which was a necessity for this investigation. A follow-up experiment might forego the control of message timing, and allow the simulation to proceed in a more natural pattern while assessing situational awareness at several points along the way.

Application to other domains

Problems of rapid and appropriate resource allocation are abundant in modern society. The domain of emergency response command and control was selected because of its familiarity to the author, because of its pervasiveness in our culture, and because every emergency operations center is likely to encounter complex and unforeseen situations at some point. The principles of cognitive systems engineering and situational awareness maintenance have been applied in many other fields. In fact, the inspiration for this experiment grew from a paper reporting on the effects of visual interface variations on situational awareness in the air
traffic control domain (Palmer et al., 2008). The framework developed for this work could certainly be modified to investigate other domains where information is transferred both audibly and visually.
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APPENDIX A – SIMULATION DESIGN DETAIL

The validity of this experiment depends upon a realistic sequence of reports from a set of interactions between the needs of a variety of emergency situations and the availabilities of a limited number of emergency response resources. A simulation system was developed to produce a realistic sequence of event reports, and to provide the necessary control over the timing and complexity of those reports. The tool used to construct the simulation system was Microsoft’s Excel application. Using Excel allows for rapid prototyping and integration with the database where the detailed output of the simulation runs would be held. Moreover, the ease with which the data could be transformed into the various formats and structures needed to complete the construction of the experiment apparatus was a key feature. The Excel-based simulation took the form of a single workbook containing nine worksheets including one for setting control parameters, and a graphical monitoring facility. The remaining seven worksheets produced a set of scripts, and discrete timed activity descriptors which would later be used to evaluate participant responses. The scripts were produced in multiple formats: some for inclusion in the database to be displayed as message transcripts, and some for subsequent processing by a text-to-speech engine to generate MP3 files containing the audio messages to be delivered to participants.
A simulation run is based on the random selection of set of incidents from seven types.

The seven types are defined as requiring the various combinations of police, fire, and medical responses.

<table>
<thead>
<tr>
<th>code</th>
<th>Police</th>
<th>Fire</th>
<th>Medical</th>
<th>Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>15%</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>10%</td>
</tr>
<tr>
<td>3</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>15%</td>
</tr>
<tr>
<td>4</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>20%</td>
</tr>
<tr>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>15%</td>
</tr>
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<td>1</td>
<td>0</td>
<td>10%</td>
</tr>
<tr>
<td>7</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>15%</td>
</tr>
</tbody>
</table>

<table>
<thead>
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<th>Fire</th>
<th>Medical</th>
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</tr>
</thead>
<tbody>
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<td>4</td>
<td>2</td>
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<td>8</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>2</td>
<td>2</td>
<td>8</td>
</tr>
</tbody>
</table>

Each incident is also assigned a random location from among a set of five place names.

The location assignment is significant as resources are drawn from the nearest source in the order the incidents occur. Police, fire, and medical resources are evenly split between the five locations. If a resource is depleted in a particular location when a request is made, a
neighboring location’s resources will be utilized, with additional travel time requirements figured in. Each assigned resource progresses through a set sequence of status changes: dispatched, responding, on the scene, available, and at home. The timing of the status changes is determined by a normally random distribution determined by pre-set parameters which were based upon a statistical analysis of actual response data. Figure 49, below, shows a portion of the timing determination worksheet representing a single incident. Each incident has a single “header” row showing the incident time, location, and type as well as some calculated values and control parameters drawn from other worksheets.

![Figure 49 - Timing worksheet snippet showing a single incident](image)

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18 This behavior mimics the “mutual aid agreements” which provide for emergency response coverage by neighboring services.
The Header row is followed by three sections, one each for police, fire, and ambulance response. Services which are not needed for the particular incident type will not have timing values assigned. Services which are needed will have timings for each status change (represented in the column labeled “code”) calculated from the normal distribution parameters shown in the rightmost three columns.¹⁹

The incident event timings are then copied into a rough scripting worksheet, a portion of which is shown below in Figure 50. In this stage, two new sets of data are added in. First, an “event order” column utilizes the event timings of all incidents and their associated resource status changes. Second, the wording of a script is rendered, albeit in a fragmented structure. The specific choice of words (e.g.: “police car” vs. “police unit”) are chosen with equal likelihood for each line of the script, emulating actual radio conversation style.

<table>
<thead>
<tr>
<th>Incident number</th>
<th>Incident type</th>
<th>Incident location</th>
<th>Event order</th>
<th>Event time</th>
<th>Event part one</th>
<th>Event part two</th>
<th>Event part three</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>1</td>
<td>00:00:00:00</td>
<td>There is a new robbery incident in the Franklin area.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>2</td>
<td>00:00:13:00</td>
<td>Police unit has been dispatched to the robbery in Franklin.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>3</td>
<td>00:00:44:00</td>
<td>Police car is enroute.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>6</td>
<td>00:02:46:00</td>
<td>Police car is on scene.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>35</td>
<td>00:12:52:00</td>
<td>Police unit is available.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>robbery</td>
<td>Franklin</td>
<td>37</td>
<td>00:13:20:00</td>
<td>Police car is back at base.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 50 - Snippet of the rough script worksheet

From the rough script, a sorted script worksheet is produced, which includes the same basic information but is sorted according to the timing of each event. A snippet of the sorted

¹⁹ Though it was not necessary with the distribution parameters used in this simulation, an additional constraint to limit the minimum amount of time. With lower values of those parameters, an unlimited distribution would permit paradoxical timings: an ambulance could arrive before it was dispatched.
script worksheet is shown in Figure 51 below. This worksheet eliminates the extraneous rows for services which are not utilized for each incident and re-arranges the events into chronology order, revealing the overlapped timings of all of the incident events. Also at this stage, a timing control necessary for this particular experiment model is introduced. The controlled time is shown in the right-most column of Figure 51, and represents the timing in seconds from the beginning of the simulation that the event should occur. The controlled timings are generated by a normally random distribution with parameters determined by the experiment’s constraints. In the snippen shown, the controlled timings have an average of ten seconds between them with a standard deviation of two seconds.

<table>
<thead>
<tr>
<th>event order</th>
<th>event time</th>
<th>event part one</th>
<th>event part two</th>
<th>event part three</th>
<th>incident number</th>
<th>incident location</th>
<th>incident type</th>
<th>activity</th>
<th>resource type</th>
<th>controlled time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>00:00:00</td>
<td>There is a new</td>
<td>fire incident</td>
<td>in the Springfield region.</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>00:00:14</td>
<td>Fire engine</td>
<td>has been dispatched to the fire in Springfield.</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>2</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>00:00:15</td>
<td>Ambulance</td>
<td>has been dispatched to the fire in Springfield.</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>1</td>
<td>3</td>
<td>31</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>00:00:46</td>
<td>Medical unit</td>
<td>is enroute.</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>00:01:14</td>
<td>Fire truck</td>
<td>is enroute.</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>51</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>00:02:11</td>
<td>There is a new</td>
<td>robbery incident</td>
<td>in the Clinton region.</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>62</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>00:02:28</td>
<td>Police unit</td>
<td>has been dispatched to the robbery in Clinton.</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>1</td>
<td>73</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>00:02:59</td>
<td>Police car</td>
<td>is enroute.</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>00:03:30</td>
<td>Medical unit</td>
<td>is on scene.</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>00:04:15</td>
<td>There is a new</td>
<td>spill incident</td>
<td>in the Clinton neighborhood.</td>
<td>3</td>
<td>5</td>
<td>3</td>
<td>305</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>00:04:29</td>
<td>Fire unit</td>
<td>has been dispatched to the spill in Clinton.</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>115</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>00:04:31</td>
<td>Police car</td>
<td>has been dispatched to the spill in Clinton.</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>129</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>00:04:59</td>
<td>Police unit</td>
<td>is enroute.</td>
<td>3</td>
<td>5</td>
<td>2</td>
<td>1</td>
<td>134</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>00:05:19</td>
<td>Police car</td>
<td>is on scene.</td>
<td>2</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>144</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The next stage of the simulation process is a resource assignment matrix which is used to determine which of the available resources is to be assigned to each incident. When two or more resources are equally viable possibilities for assignment, they are assigned according to a
flat random distribution. If a needed resource is not available in the same region as the incident, a resource from a neighboring area is drawn, and the travel time in increased appropriately. (Though the controlled timing described above for this particular experiment renders this moot.)

With specific resources assigned, a finished script can be composed, and is represented in Figure 52. The completed messages from the finished script are fed into another worksheet which imbeds them into a command script which will render them as MP3 sound files from a text-to-speech engine.

<table>
<thead>
<tr>
<th>Order</th>
<th>Time</th>
<th>Incident Number</th>
<th>Incident Type</th>
<th>Incident Location</th>
<th>Resource Type</th>
<th>Resource ID</th>
<th>New Status</th>
<th>Complete message</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>10</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>There is a new fire incident in the Springfield region.</td>
</tr>
<tr>
<td>2</td>
<td>21</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>2 eight</td>
<td>1</td>
<td>1</td>
<td>Fire engine number eight has been dispatched to the fire in Springfield.</td>
</tr>
<tr>
<td>3</td>
<td>31</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>3 seven</td>
<td>1</td>
<td>1</td>
<td>Ambulance number seven has been dispatched to the fire in Springfield.</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>3 seven</td>
<td>2</td>
<td>1</td>
<td>Medical unit number seven is enroute.</td>
</tr>
<tr>
<td>5</td>
<td>52</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>2 eight</td>
<td>2</td>
<td>2</td>
<td>Fire truck number eight is enroute.</td>
</tr>
<tr>
<td>6</td>
<td>62</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>There is a new robbery incident in the Clinton region.</td>
</tr>
<tr>
<td>7</td>
<td>73</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>1 eight</td>
<td>1</td>
<td>1</td>
<td>Police unit number eighteen has been dispatched to the robbery in Clinton.</td>
</tr>
<tr>
<td>8</td>
<td>84</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>1 eight</td>
<td>2</td>
<td>2</td>
<td>Police car number eighteen is enroute.</td>
</tr>
<tr>
<td>9</td>
<td>94</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>3 seven</td>
<td>3</td>
<td>3</td>
<td>Medical unit number seven is on scene.</td>
</tr>
<tr>
<td>10</td>
<td>101</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>There is a new spill incident in the Clinton neighborhood.</td>
</tr>
<tr>
<td>11</td>
<td>113</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2 ten</td>
<td>1</td>
<td>1</td>
<td>Fire unit number ten has been dispatched to the spill in Clinton.</td>
</tr>
<tr>
<td>12</td>
<td>122</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1 twenty</td>
<td>1</td>
<td>1</td>
<td>Police car number twenty has been dispatched to the spill in Clinton.</td>
</tr>
<tr>
<td>13</td>
<td>133</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>1 twenty</td>
<td>2</td>
<td>2</td>
<td>Police unit number twenty is enroute.</td>
</tr>
<tr>
<td>14</td>
<td>142</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>1 eight</td>
<td>3</td>
<td>3</td>
<td>Police car number eighteen is on scene.</td>
</tr>
<tr>
<td>15</td>
<td>151</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>2 eight</td>
<td>3</td>
<td>3</td>
<td>Fire engine number eight is on scene.</td>
</tr>
<tr>
<td>16</td>
<td>160</td>
<td>3</td>
<td>2</td>
<td>5</td>
<td>2 ten</td>
<td>2</td>
<td>2</td>
<td>Fire unit number ten is enroute.</td>
</tr>
</tbody>
</table>

Figure 52 - Snippet of finished script
The simulation process retains details of activity such as the number of concurrent incidents in each region, of each type, etc. These values are aggregated and displayed graphically on a final worksheet, shown in Figure 53 below.

Figure 53 - Graphical simulation monitoring worksheet

The ultimate output of the simulation system is a database containing the timing-controlled scripts with accompanying status information for each event within the simulations. The database also contains references to the MP3 audio files produced by the text-to-speech scripts. The database is used as the foundation for the experiment’s data collection and analysis systems.
APPENDIX B – INTERFACE DESIGN DETAIL

The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness

Welcome and thank you for visiting my "user interface experiment" web page. This study is being conducted for research purposes, and research participants are being sought. Anyone able to use a typical personal computer and web browser may participate.

I am working toward a Ph.D. in Information Sciences and Technology at the Pennsylvania State University. This web application is the data gathering component of an experiment I am conducting as a part of that effort. I very much appreciate your time, and I have arranged for a set of drawings to be held, awarding gift certificates, to randomly selected participants who complete the experiment. Here is what is involved:

The next page will apprise you of your rights as a participant in this study, and allow you to gracefully decline to participate. If you continue (please do), the following page will provide some more details and gather preliminary information from you. You will then be taken to a web page which you will use to record activity into a database. The activities I will ask you to record will come as audio messages which will start out slow and then get faster and faster. The messages will describe the simulated activity of emergency resources (police, fire, and medical) in a fictional city. I am interested in the speed and accuracy of your understanding of the audio messages. The entire process should take about twenty minutes.

Once you have completed the experiment, you will be shown a score and ranking, so you can get an idea of how well you did compared to others who have participated. At this point, you will have the option to submit an email address which will be entered into a couple of random drawings for prizes to be held at the conclusion of the study. If you submit an email address, it will be included in a drawing from all submissions. In addition, if your score is in the top 25% of all the scores, the submitted email address will be included in a separate drawing for another prize. Prizes will be gift certificates for a variety of businesses, ranging in values from $10 to $50. (Please note: The email address you supply and the score you achieve will not be correlated with any other data you provide through the course of the experiment.)

If you have any questions or concerns regarding this research, please contact:
Art Jones
111B Keller Building
University Park, PA 16802
email: ajones@pstat.psu.edu

Figure 54 - A screenshot of the "welcome" page
Informed Consent

Title of Project:
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Satisfaction: AWARENESS
This research project is in partial fulfillment of the requirements for a Ph.D. degree through The Pennsylvania State University’s College of Information Sciences and Technology.
This study is being conducted for research purposes.

Primary Investigator:
Arthur C. Jones, Ph.D., BTM-P, Ph.D. Candidate
College of Information Sciences and Technology
The Pennsylvania State University
115 E Keller Building, University Park, PA 16802
e-mail: ajones@psu.edu
phone: 814-395-3003

Other Investigator(s):
Dr. Michael D. McNeese, Ph. D. (faculty advisor / committee chair)
College of Information Sciences and Technology
The Pennsylvania State University
218-A HUB Building, University Park, PA 16802
e-mail: mcn@psu.edu
phone: 814-865-7885

Purpose:
The study will quantitatively assess the ability of subjects to interpret audio messages and record those interpretations into a database via a variety of interface designs, while simultaneously formulating situational awareness of the dynamic environment reported by the messages. Potential Benefits: These functions being studied are derived from the activities of emergency operations center personnel, who may benefit from improved information management techniques resulting from this study.

Procedures:
You will be led through the collection of some basic demographic information, any piece of which you may refuse to answer without penalty. You will then be taken to a web page which you will use to record activity into a database. The activities you will be asked to record will come as audio messages which will start out slow and then get faster and harder. The messages will describe the simulated activity of emergency resources (police, fire, and medical) in a fictional city. The speed and accuracy of your submissions will be recorded for analysis. At random times, the simulation will freeze and you will be asked to supply some information designed to test your understanding of the simulated situation. There are no risks or discomforts foreseen in the procedures of this study.

Compensation:
At the conclusion of your session, you will have the option to submit an email address which will be entered into a set of random drawings for gift cards to be held at the conclusion of this study. There will be two distinct drawings, each with three winners of equal value.
The first drawing will be inclusive of all participants who complete the study, and elect to submit an email address for inclusion in the drawings. The second, “bonus drawing,” will be inclusive of all participants who score at or above the 75th percentile of all participants, and who elect to submit an email address for inclusion in the drawings. Please be aware that total payments within one calendar day that exceed $50 will require the University to report those payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income.

Time Requirements:
Complete participation in a session will take approximately 20-30 minutes.

Confidentiality:
Your confidentiality will be kept to the degree permitted by the technology being used. No guarantee can be made regarding the interception of data sent via the internet by any third parties. No personally identifiable information will be collected. The data collected will be confidential and stored in a secure database. In the event of any publication or presentation resulting from this research, no personally identifiable information will be disclosed. Email addresses collected for inclusion in the drawings for prizes at the conclusion of this study will be held distinctly from the other collected data, and will be used only for the specified purpose. Addresses will not be shared with any person or organization besides the P.I., and will be deleted following the prize drawings.

Participation:
Participation is voluntary. Participants may refuse to answer any question and may withdraw their participation at any time. (This is only for my study coming to participants’s study and/or closing the browser session.) You must be at least 18 years of age to participate in this study.

Questions:
Participants have the right to ask questions and have these questions answered. Any questions regarding this research must be directed to the primary investigator named above. If you have questions about your rights as a research participant, contact Penn State’s Office for Research Protections at 814-865-1775. If you feel you have been harmed in any way by your participation in this study, please contact the P.I. named above or Penn State’s Office for Research Protections.

Acknowledgement:
By clicking on the "Agree" button below, you acknowledge that you have read and understand all of the points listed on this page. You are encouraged to print this page for your own records.

Figure 55 - A screenshot of the "informed consent" page
Figure 56 - A screenshot of the "demographics" page
Figure 57 - Interface #1 screenshot
Figure 58 - Interface #2 screenshot
Figure 59 - Interface #3 screenshot
Now, I'd like you to answer a few questions regarding your perception of the situation you have been following. Please fill in the values below as best as you can. If you are unsure of any value, please enter your best guess.

<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Currently Underway</th>
<th>Most Occurred</th>
<th>Least Occurred</th>
<th>Current Busiest</th>
<th>Overall Busiest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accident</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Chemical Spill</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fight</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Robbery</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fire</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fallen Tree</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Medical Emergency</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Region</th>
<th>Currently Going On</th>
<th>Busiest So Far</th>
<th>Overall Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Franklin</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Salem</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Washington</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Springfield</td>
<td></td>
<td>○</td>
<td></td>
</tr>
<tr>
<td>Clinton</td>
<td></td>
<td>○</td>
<td></td>
</tr>
</tbody>
</table>

Figure 60 - A screenshot of the SAGAT assessment page
APPENDIX C – DATA COLLECTION AND ANALYSIS PLAN DETAIL

The experiment’s design requires a database capable of supporting the delivery of messages generated by the simulation as well as recording the interpreted meanings reported by participants.

Figure 61 - overview schematic of data collection plan
Figure 62 - webpage/database interaction schematic
Figure 63 - Experiment database schema diagram
APPENDIX D – CRANE’S ALERT SCALE OF COGNITIVE STYLE

The questions posed in the assessment are these:

1. A) It’s fun to take risks.
   B) I have fun without taking risks.

2. A) I look for new ways to do old jobs.
   B) When one way works well, I don't change it.

3. A) I begin many jobs that I never finish.
   B) I finish a job before starting a new one.

4. A) I'm not very imaginative in my work.
   B) I use my imagination in everything I do.

5. A) I can analyze what is going to happen next.
   B) I can sense what is going to happen next.

6. A) I try to find the one best way to solve a problem.
   B) I try to find different answers to problems.

7. A) My thinking is like pictures going through my head.
   B) My thinking is like words going through my head.

8. A) I agree with new ideas before other people do.
   B) I question new ideas more than other people do.

9. A) Other people don't understand how I organize things.
   B) Other people think I organize well.
10. A) I have good self-discipline.
    B) I usually act on my feelings.

11. A) I plan time for doing my work.
    B) I don't think about the time when I work.

12. A) With a hard decision, I choose what I know is right.
    B) With a hard decision, I choose what I feel is right.

13. A) I do easy things first and important things later.
    B) I do the important things first and the easy things later.

14. A) Sometimes in a new situation, I have too many ideas.
    B) Sometimes in a new situation, I don't have any ideas.

15. A) I have to have a lot of change and variety in my life.
    B) I have to have an orderly and well-planned life.

16. A) I know I'm right, because I have good reasons.
    B) I know I'm right, even without good reasons.

17. A) I spread my work evenly over the time I have.
    B) I prefer to do my work at the last minute.

18. A) I keep everything in a particular place.
    B) Where I keep things depends on what I'm doing.

19. A) I have to make my own plans.
    B) I can follow anyone's plans.
20. A) I am a very flexible and unpredictable person.
   B) I am a consistent and stable person.

21. A) With a new task, I want to find my own way of doing it.
   B) With a new task, I want to be told the best way to it.

In order to calculate a score, add one point for each time you answered "A" for questions: 1, 2, 3, 7, 8, 9, 13, 14, 15, 19, 20, 21, and one point for each time you answered "B" for questions: 4, 5, 6, 10, 11, 12, 16, 17, 18. A score of 0 to 4 indicates a strong left brain dominance; 5 to 8 indicates a moderate left brain dominance; 9 to 13 indicates no dominance by either side; 14 to 16 indicates a moderate right brain dominance, and 17 to 21 indicates a strong right brain dominance. (Crane, 1989)
APPENDIX E – INSTITUTIONAL REVIEW BOARD DOCUMENTATION

IRB Application for Expedited Approval
APPLICATION FOR THE USE OF HUMAN PARTICIPANTS
EXPEDITED & FULL REVIEWS

Form Instructions:
- To complete the form, press TAB or SHIFT TAB between boxes and enter an 'X' or text. For assistance, contact the Office for Research Protections.
- This application will ask general questions about your study. Depending on your response, additional appendices may need to be completed in order to provide more detailed information. For example, if you indicate that your study involves prisoners, Appendix 4 will also need to be completed and submitted.
- Submit recruitment materials, informed consent forms, and all other materials as attachments to the application. Do NOT include within the application.
- Handwritten applications will NOT be accepted.

Project Title:
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness

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| College: IST | Campus: UP |
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| Faculty Advisor, if PI is a student: Michael D. McNeese | PSU User ID (e.g., abc123): mdm25 |
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| Dept: IST | College: IST |
| Mailing Address: 325-A IST Building, University Park, PA. 16802 |

Is there anyone you wish to include on correspondence related to this study (e.g., a study coordinator, etc.):

| Name: | PSU User ID (e.g., abc123): |
| University Status (Faculty, Staff, Student, etc.): | Telephone Number: |
| Email Address: | Dept: |
| College: | Campus: |
| Mailing Address: | Role in this study: Choose one of the following |

This form is available electronically at http://www.research.psu.edu/protecthuman/applications/index.asp
A. Funding:
1. Is this research study internally or externally funded?  
☐ Yes  ☐ No  ☐ N/A
☐ No → Skip to Question 6
☐ Pending → Answer Questions 2 – 5

2. Provide the name and mailing address of internal and external sources of funding. Provide a copy of your grant proposal with the application. If a copy of the grant proposal is not included, explain.

3. Is the sponsor providing the drug, device, etc. free of charge?  
☐ Yes  ☐ No  ☐ N/A

4. Has the sponsor agreed to pay for direct costs of treating injuries?  
☐ Yes  ☐ No

5. If funding is not awarded, will the research still be conducted?  
☐ Yes  ☐ No  ☐ N/A

B. Conflict of Interest:
6. On any of the investigator(s), key personnel, and/or their spouses or dependent children have a conflict of interest (COI), as defined by PSU Policy RA20, "Individual Conflict of Interest," associated with this research?  
☐ Yes → Complete & Submit Appendix 1, Section A  
☐ No

7. Does PSU have an ownership or royalty interest in any intellectual property related to this study?  
☐ Yes → Complete & Submit Appendix 1, Section B  
☐ No

8. Are there any other significant conflicts that could possibly affect or be perceived to affect this study?  
☐ Yes → Complete & Submit Appendix 1, Section C  
☐ No

C. Class Projects:
9. Is this a class project?  
☐ Yes → Provide the following information:
   • Instructor's Name:
   • Course Title and Number:
   • Semester course is being offered:
   ☐ No

D. Review Level:
10. What level of review do you expect this research to need?  
☐ Expedited Review → Answer Question 11  
☐ Full Review → Skip to Question 12

11. Expedited Research Categories: Read the following categories and choose one or more that apply to your research. Your research must fit in at least one category and be no more than minimal risk in order to be considered for an expedited review.

☐ Category 1: Clinical studies of drugs and medical devices only when condition (a) OR (b) is met.
   (a) Research on drugs for which an investigational new drug application (21 CFR 312) is not required. (Research on marketed drugs that significantly increases the risks or decreases the acceptability of the risks associated with the use of the product is not eligible for expedited review.)
(b) Research on medical devices for which (i) an investigational device exemption application (21 CFR 812) is not required; or (ii) the medical device is cleared/approved for marketing and the medical device is being used in accordance with its cleared/approved labeling.

☐ Category 2: Collection of blood samples by finger stick, heel stick, ear stick or venipuncture as follows:
(a) From healthy, non-pregnant adults who weigh at least 100 pounds. For these participants, the amounts drawn may not exceed 550 ml in an 8 week period and collection may not occur more frequently than 2 times per week.
(b) From other adults and children, considering the age, weight, and health of the participants, the collection procedure, the amount of blood to be collected, and the frequency with which it will be collected. For these participants, the amount drawn may not exceed the lesser of 50 ml or 3 ml per kg in an 8 week period and collection may not occur more frequently than 2 times per week.

☐ Category 3: Prospective collection of biological specimens for research purposes by non-invasive means. Examples include:
- Hair and nail clippings in a non-disfiguring manner;
- deciduous teeth at time of exfoliation or if routine patient care indicates a need for extraction;
- Permanent teeth if routine patient care indicates a need for extraction;
- Excreta and external secretions (including sweat);
- Unanesthetized saliva collected either in an unstimulated fashion or stimulated by chewing gumbase or wax or by applying a dilute citric solution to the tongue;
- Placenta removal at delivery;
- Amniotic fluid obtained at the time of rupture of the membrane prior to or during labor;
- Supra- and subgingival dental plaque and calculus, provided the collection procedure is not more invasive than routine prophylactic scaling of the teeth and the process is accomplished in accordance with accepted prophylactic techniques;
- Mucosal and skin cells collected by buccal scraping or swab, skin swab, or mouth washings;
- Sputum collected after saline mist nebulization.

☐ Category 4: Collection of data through non-invasive procedures (not involving general anesthesia or sedation) routinely employed in clinical practice, excluding procedures involving x-rays or microwaves. Where medical devices are employed, they must be cleared/approved for marketing. Studies intended to evaluate the safety and effectiveness of the medical device are not generally eligible for expedited review, including studies of cleared medical devices for new indications. Examples include:
- Physical sensors that are applied either to the surface of the body or at a distance and do not involve input of significant amounts of energy into the participant or an invasion of the participant's privacy;
- Weighing or testing sensory acuity;
- Magnetic resonance imaging;
- Electrocardiography, electroencephalography, thermography, detection of naturally occurring radioactivity, electroretinography, ultrasound, diagnostic infrared imaging, doppler blood flow, and echocardiography;
- Moderate exercise, muscular strength testing, body composition assessment, and flexibility testing where appropriate given the age, weight, and health of the individual.

☐ Category 5: Research involving materials (data, documents, records, or specimens) that have been collected or will be collected solely for non-research purposes (such as medical treatment or diagnosis).

☐ Category 6: Collection of data from voice, video, digital, image recordings made for research purposes.

☒ Category 7: Research on individual or group characteristics or behavior (including but not limited to research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

E. Research Personnel:

NOTE:
- The Principal investigator is responsible for ensuring that all individuals conducting procedures described in this application are trained adequately prior to involving human participants.
- All personnel listed on this application who (1) are responsible for the design/conduct of the study, (2) have access to the human participants (i.e., will consent participants, conduct the study), or (3) will have access to identifying AND confidential information must successfully complete the IRB's Training on the Protection of Human Participants or provide verification of training from their home institution. PSU'S training may be located at [Link]. Approval will NOT be
granted until all individuals have successfully completed the training. Verification of training does NOT need to be sent in if the individual completed the Penn State's training.

- As personnel change, you must submit a Modification Request Form – Expedited & Full Review to add or remove personnel.

12. Provide the name of the other individual(s) assisting with this study who (1) will be responsible for the design/conduct of the study, (2) have access to the human participants (i.e., will consent participants, conduct the study), or (3) have access to identifying AND confidential information. If the individual does not have a PSU Access User ID, please provide some other form of contact information. If additional space is needed, attach a separate sheet containing the same information.

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<th>Name</th>
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<th>PSU User ID (e.g., abc 123)</th>
<th>Mailing Address</th>
<th>Role in this Study</th>
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13. Identify (1) the procedures/techniques each person (including advisors) listed in Question 12 and on the first page of the application will perform and (2) describe their level of research experience.

The P.I. is a Ph.D. candidate in the College of Information Sciences and Technology with prior experience in proper data-collection procedures and protocols. The P.I. is responsible for all aspects of this study, including overall experiment design, apparatus development, data collection, and analysis.

The co-P.I. is a tenured faculty member in the College of Information Sciences and Technology, who is involved in the P.I.'s academic advisor and dissertation committee chairperson. The co-P.I. will not be involved in the administration of this study, but will serve as an advisor regarding specific procedures and techniques for implementation and analysis.

14. Explain how the persons assisting with this research are kept adequately informed about the study and their research-related duties and functions.

The co-P.I. will be kept abreast of the progress and developments of this study via e-mail, phone conversations, and/or in-person conversations on a mutually convenient schedule not less than once every two weeks throughout the duration of the data collection.

F. Purpose & Procedures:

15. Provide a detailed description of the research that includes (1) the background, (2) aims/objectives [hypothesis], and (3) a description of how the research will be conducted [methodology – what participants will be asked to do].

The study will quantitatively assess the ability of subjects to interpret audio messages and record those interpretations into a database via a variety of interface designs, while simultaneously formulating situational awareness of the dynamic environment reported by the messages. These functions are derived from the activities of emergency operations center personnel, who may benefit by improved information management techniques resulting from this study.

The goal of this study is to describe the relative values of variations in human-computer interfaces for the purpose of maintaining an accurate and up-to-date digital representation, and individual situation awareness, of a particular environment.

Procedure:

1. Audio messages will provide information regarding an emergency incident: “There is a house fire in the orange neighborhood.” Follow-up messages will follow specific resources (police/fire/ambulance units) through the cycle of their response to the incident.
"Police unit seven is enroute."... "Ambulance unit three is on scene"... "Police unit seven is on scene."... etc.

2. The timing of the messages will be controlled by the simulation. Messages will arrive at a "slow" rate for a period of time, and then increase in frequency and sustain a "fast" rate for a period of time.

3. Participants will have to record the sequence of events into a database via user interfaces which will vary among a set of three models: enhanced text (drop-down selection lists), graphical, and graphical enhanced with (simulated) speech recognition.

4. Following the situation awareness global assessment technique (SAGAT) guidelines, the simulation will periodically freeze, blank all displays, and request information designed to assess their situation awareness. The simulation will then resume from the freeze-point.

5. At the conclusion of a participant's session, they will be presented with a score of their performance and asked if they would like to be included in the drawings, which will be conducted at the conclusion of the data collection period.

6. If a participant does wish to be included in the drawings, they will be asked to supply an e-mail address where they can be notified if they are chosen as a drawing winner. This address, along with their score, will be stored in a database table distinct from those containing their specific performance measures, maintaining a separation between a participant's measures and their personally-identifying data.

16. How long will participants be involved in this research study? Include the number of sessions and the duration of each session.

Each session will last 20-30 minutes. Participants may undertake multiple session, if they wish.

17. Where will this research study take place? Choose all that apply.

☑ University Park → Specify the building and room number. If not yet known, indicate such.
☑ GCRC at University Park
☑ Other PSU Campus Location → Specify the campus, building and room number. If not yet known, indicate such.

☑ Hershey Medical Center → Specify the building and room number. If not yet known, indicate such.
☑ GCRC at the Hershey Medical Center
☑ Mt. Nittany Medical Center
☑ Other Site(s) → Explain.

unknown

specifics are not known at this time; I have contacts at DuBois, Abington, Harrisburg, Behrend, and New Kensington campuses where I may recruit subjects if needed - see below

This study is web-based, allowing participation from any location with web access. Standard classroom participation will be encouraged.

NOTE: For other sites such as schools, doctor offices, businesses, etc., the IRB requires that research conducted at these sites be approved by an individual in a decision making position at the site. Documented approval (i.e., a letter of agreement) is required.

18. Is this a multi-center study outside of PSU?

☐ Yes → Answer Question 19
☒ No → Skip to Question 22

19. Is any Penn State investigator on this application the lead investigator (project director) of this multi-center study?

☐ Yes → Answer Questions 20 – 21
20. Provide the name and location of all other centers. Copies of IRB approval letters from each site will be required with the supporting documentation for this application.

21. Describe the plan for the management and communication of multi-site information that may be relevant to the protection of participants (e.g., unanticipated problems, adverse events, interim analyses, modifications).

22. How will the data be analyzed?
   The collected data will undergo typical ANOVA analysis.

23. List criteria for inclusion of participants.
   Participants are expected to healthy adults of average intelligence.

24. List criteria for exclusion of participants:
   1. physical ailments which would prevent a subject from typical use of a standard multi-media computer interface (e.g.: vision or hearing defects, arthritis)
   2. prior experience in multi-modal command and control operations centers

G. Participants:
25. Maximum number of participants/samples/charts to be enrolled at this institution (Enter one number – not a range): 120

26. Was a statistical/power analysis conducted to determine the adequate sample? □ Yes □ No

27. Does this research exclude any particular:
   Gender Identity □ Yes □ No If Yes, please explain.
   Racial/ethnic groups □ Yes □ No If Yes, please explain.
   Sexual Orientation □ Yes □ No If Yes, please explain.

28. Age range – Choose all that apply:
   □ Less than 1 year    □ 7 – 12 years    □ 18 – 25 years    □ 40 – 65 years
   □ 1 – 6 years        □ 13 – 17 years    □ 26 – 40 years    □ 65+ years

29. Choose all categories of participants who will be involved in this research study:
   □ Healthy volunteers
   □ Penn State students
   □ Subject Pool Students – Indicate the subject pool: □ CAS 100A □ Psychology – UP □ Psychology – Behrend
   □ Will all participants involved in this study be from the subject pool? □ Yes □ No
   □ Children – Individuals under the age of 18 Complete & Submit Appendix 4
   □ International Research – participants live outside of the U.S. Complete & Submit Appendix 4
   □ Prisoners Complete & Submit Appendix 4
   □ Pregnant Women Complete & Submit Appendix 4
   □ Women of reproductive potential at the time of this research – Choose one of the following:
     □ The research poses no added risk associated with pregnancy and/or lactation
     □ Precautions against pregnancy and/or lactation, and pregnancy tests are addressed in the research proposal and consent form
   □ Patients Complete & Submit Appendix 4
   □ Individuals with a decisional impairment who are targeted for this study (e.g., research on Alzheimer’s) Complete & Submit Appendix 6
   □ Individuals with a decisional impairment who are NOT targeted for this study (e.g., decisionally compromised person eligible for a study on a new treatment for breast cancer) Complete & Submit Appendix 6
   □ Institutionalized individuals (e.g., patients in state hospitals or nursing homes) Complete & Submit Appendix 7
30. Will participants be currently enrolled in a course/class of any personnel listed on this application?
   □ Yes → Describe the measures taken to avoid coercion & undue influence: this is a possibility, however, the collected data will be anonymous - there will be no record of an individual's participation, or non-participation.
   □ No

31. Will participants be employees of any personnel listed on this application?
   □ Yes → Describe the measures taken to avoid coercion & undue influence: 
   □ No

32. Could some or all participants be vulnerable to coercion or undue influence due to special circumstances? Do not include children, decisionally impaired persons, and prisoners in your answer.
   □ Yes → Describe the measures taken to protect these individuals: 
   □ No

H. Recruitment:
33. Indicate the types of recruitment that will be done for this research & attach copies of the materials. Choose all that apply:
   □ Newspaper/magazine ads
   □ Radio/TV ads
   □ Letters/Emails to potential participants

   → Explain how potential participants contact information was obtained: Electronic correspondence will only be with persons with whom I am previously acquainted, and in accordance with University policies AD20 & AD56. There will be no "blind" e-mail or other electronic messages sent with the intention of recruitment.

   □ Letters/Emails to healthcare professionals for recruitment purposes
   □ Flyers/posters → Where will the items be displayed/distributed?
   □ Brochures → Where will the items be displayed/distributed?
   □ Web sites → List the sites the recruitment materials will be posted: Facebook
   □ Email via Listserv → Has permission been obtained from the listserv administrator? □ Yes □ No
   □ Script → Verbal (i.e., telephone, face-to-face, classroom)
   □ Subject Pool → Indicate which subject pool will be used:
     □ CAS 100A □ Psychology – UP □ Psychology – Behrend
     → Note: If you are not a member of the subject pool's department, a permission letter will be needed.
   □ Other → Explain:

34. Who will approach and/or respond to potential participants?
The P.I.

35. Before potential participants sign a consent form, are there any screening questions that will be asked to determine whether an individual is appropriate for the study?
   □ Yes → Answer Question 36
   □ No → Skip to Question 37

36. During screening questions, will identifiable information about these individuals be recorded?
   □ Yes → Complete & Submit Appendix B
   □ No
37. Will investigators access medical charts and/or hospital/clinic databases for recruitment purposes?
   - Yes → Answer Question 38
   - No → Skip to Question 39

38. Has a waiver of authorization to access protected health information been requested?
   - Yes
   - No → Explain why a waiver of authorization has NOT been requested.

39. Will physicians/clinicians provide identifiable, patient information (e.g., name, telephone number, address) to investigators for recruitment purposes?
   - Yes → Provide a copy of the written authorization release form for review.
   - No

I. Consent:
40. When and where will participants be approached to obtain informed consent/assent [include the timing of obtaining consent in the response]? If participants could be non-English speaking, illiterate or have other special circumstances, describe. Attach a copy of the informed consent/assent form(s).
   
   Informed consent information is provided on the first page of the data-gathering web application. Text of this page is attached.

41. Who will be responsible for obtaining informed consent/assent from participants?
   [automated via web-based application]

42. Do the people listed in Question 41 above speak the same language as the participants?
   - Yes
   - No → Explain how consent will be obtained.

43. What type of consent will be obtained? Choose all that apply.
   - Signed consent – participant will sign consent form
   - Implied consent – participant will not sign consent form (e.g., mail survey, email, online interview)
   - Complete & Submit Appendix 9, Section A
   - Verbal consent – participant gives consent verbally (e.g., in-person interview, telephone interview)
   - Complete & Submit Appendix 9, Section B
   - Passive/Opt Out consent – participant only required to act if they do not want to participate
   - Complete & Submit Appendix 9, Section C
   - Complete waiver of informed consent
   - Complete & Submit Appendix 9, Section D
   - Other → Describe:

44. If multiple groups of participants are being utilized (i.e., teachers, parents, children, people over 18), who will and will not sign the assent/consent form? Specify for each group of participants.
   Everyone must acknowledge the informed consent information to begin the experiment.

45. Participants are to receive a copy of the informed consent form with the approval box/statement on it. Describe how participants will receive a copy of the informed consent form to keep for their records.
   Participants will be advised of their ability to print a copy of the informed consent information from the website on which it is presented.

J. Payment for Participation:
46. Indicate the type and amount of payment for participation that will be offered. Choose all that apply.
   - Money
   - Gift Certificate
   - Extra/Class Credit (e.g., 5 points, 1% of final grade)
   - Drawing
   - Amount: $0
   - Amount: $10-$50
   - Skip to Question 48
   - Skip to Question 47
   - Skip to Question 48
   - Explain: A set of random drawings, each for a gift certificate or small
prize, will be used to encourage participation and performance for each category of the experiment's primary parameter. The drawings will be made from participants who express their desire to be included, following the completion of the data collection segment, by submitting their e-mail address via a web-based form. The participants' e-mail addresses will not be correlated with any of the other data collected as part of the experiment's procedures.

☐ Other (e.g., merchandise)
☐ Compensation will NOT be offered

47. An alternative, equal in time and effort, must be offered in place of participating in the research. Describe the alternative available for earning the extra/credit. The description should include the length of time it will take to complete the alternative as well as how undue influence will be prevented.

☐ Yes → Explain how payment will be pro-rated:
☒ No

K. Data Collection Measures/Instruments:
49. Choose any of the following data collection measures/instruments that will be used in this study. Attach a copy of all instruments/measures, interview and focus group topics/questions to the application.
☐ Biological Specimens – blood, urine & other human derived samples
☐ Biomedical Devices – EEG, EKG, MRI
☐ Diaries/Journals completed by the participants
☐ Focus Groups
☐ Individual Interviews
☐ Knowledge/Cognitive Tests
☐ Observations
☐ Physical Testing Measures – Height, Weight, Body Mass Index, Blood Pressure
☐ Questionnaires/Surveys – Mail, Internet, Telephone, Email, Paper/Pencil
☒ Other → Explain. Data will be collected via a web-based application (note: this is not a survey)

50. Will participants be assigned to groups?
☐ Yes → Answer Questions 51 – 52
☒ No → Skip to Question 54

51. Will a control group(s) be used?
☐ Yes → Choose one of the following:
☐ Placebo control
☐ Standard therapy control
☐ Other control method → Explain:
☒ No

52. Is the research a blinded (masked) study?
☐ Yes → Answer Question 53
☒ No → Skip to Question 54

53. Is emergency unblinding permitted?

This form is available electronically at http://www.research.cmu.edu/instethicsems/applications/index.jsp
L. Recordings – Audio, Video, Photographs
54. Will any type of recordings (audio or video) or photographs be made during this study?
☐ Yes → Complete & Submit Appendix 10
☐ No

M. Computer/Internet
55. Will any participant interaction in this study be conducted on the Internet or via email (e.g., on-line surveys, observations of chat rooms or blogs, on-line interviews)?
☐ Yes → Complete & Submit Appendix 11, Section A
☐ No

56. Will a commercial server (i.e., SurveyMonkey, PsychData, Zoomerang) be used to collect data or for data storage?
☐ Yes → Complete & Submit Appendix 11, Section B
☐ No

N. Discomforts and Risks
57. List all of the potential discomforts and risks (physical, psychological, legal, social or financial) and describe the likelihood or seriousness of the discomforts/risk. If there are no discomforts/risks, state such.

There are no foreseen risks or discomforts.

58. Describe how risks will be minimized and/or how participants will be protected against potential risks throughout the study.

59. Does this research involve greater than minimal risk to the participants?
☐ Yes → Study must be reviewed by the Full IRB at a convened meeting.
☐ No

60. Will medical or psychological care be available for participants who may require it as a result of the study?
☐ Yes → Identify the source of medical or psychological care available – include address & telephone number.
☐ No → Explain why medical or psychological care will NOT be available: there is no foreseen need

61. Does the research protocol have a plan for routine analysis or monitoring of the data and safety of this research study?
☐ Yes → Complete & Submit Appendix 17
☐ No → For studies involving greater than minimal risk, a plan will need to be developed for review and approval at the convened IRB meeting.

O. Benefits
62. What are the potential benefits to the individual participants? If none, state such. PLEASE NOTE: Payment for participation cannot be considered a benefit.

none

63. What are the potential benefits to society? If none, state such.

improved information management systems in emergency operations centers.

64. Explain how the benefits outweigh the risks.

risks are minimal

P. Reporting
65. Is it possible investigators will discover a participant’s previously unknown condition (e.g., disease, suicidal thoughts, wrong paternity) as a result of study procedures?

This form is available electronically at http://www.research.uic.edu/ireb/humanapplication/index.htm
66. Is it possible investigators will discover a participant is engaging in illegal activities (e.g., drug use, domestic violence, child abuse/neglect, underage drinking) as a result of study procedures?
   ☑ Yes → Explain how and when such a discovery will be handled:
   ☐ No

67. Does this study involve giving false or misleading information to participants or withholding information from them such that their "informed" consent is in question?
   ☑ Yes → Complete & Submit Appendix 12
   ☐ No

R. Confidentiality and Privacy

68. Describe the provisions made to maintain confidentiality of the data. Choose all that apply.
   ☐ Password protected computer files
   ☐ Locked offices
   ☐ Locked file cabinets
   ☐ Other → Explain:
   ☐ Identification code (i.e., code numbers, pseudonyms) – data will NOT be associated with personal identifiers

69. Describe the provisions made to protect participants' privacy interests.

No individually-identifying data will be requested or collected through the course of the experiment's procedures. After completing their session, each participant will be given the option of supplying an e-mail address for inclusion in a set of random drawings at the conclusion of the study. These e-mail addresses will not be verified in any way at the time of submission, and will be stored in a distinct database table, uncorrelated with any of the data collected for analysis.

70. Who will have access to the data?
   Only the P.I. and faculty advisor.

71. Will identifiers be disclosed to a sponsor or collaborators at another institution?
   ☑ Yes → List the identifiers that will be disclosed and explain why this is necessary:
   ☐ No

72. Will a list containing a code (i.e., code numbers, pseudonyms) and participants' identity be used in this study?
   ☑ Yes → Answer Questions 73 – 75
   ☐ No → Skip to Question 76

73. Where will the list linking the code to participants' identity be stored and how will the list be secured?

74. Who will have access to the list linking the code to participants' identity?

75. Will the list linking the code to participants' identity be destroyed?
   ☑ Yes → When will the list be destroyed?
   ☐ No

76. What will happen to the research records when the research has been completed? Choose only one.
   ☐ Stored indefinitely with identifiers removed
   ☑ Stored indefinitely with identifiers attached
   ☐ List the identifiers that will be attached to the data:
   ☐ Stored for length of time required by federal regulations/funding source & then destroyed (minimum of 3 years)
   ☐ Destroyed after a number of years (minimum of 3 years) → Specify the number of years:
   ☐ Destroyed when notified by sponsor
Box Other: Explain. E-mail addresses supplied for inclusion in the drawings will be deleted as soon as gift certificates are distributed.

71. Could the information being collected for this study have adverse consequences for participants or be damaging to their financial standing, employability, insurability or reputation?

☐ Yes → Indicate the type of information being collected:
☐ Substance abuse or other illegal risk behaviors
☐ Determination of HIV status for the research
☐ Genetic information about inheritable diseases
☐ Other → Explain:
☐ No

72. Will a "Certificate of Confidentiality" be obtained from the federal government?

☐ Yes → Indicate who will obtain the Certificate of Confidentiality
☐ Sponsor
☐ Principal Investigator
☐ Other → Explain:
☐ No

S. Health Insurance Portability & Accountability Act (HIPAA) - Use of protected health information

73. Will participant's protected health information (PHI) be obtained for this study?

☐ Yes → Complete & Submit Appendix 13
☐ No

T. Drugs, Medical Devices, and Other Substances

80. Does this research study involve drugs or biologics?

☐ Yes → Complete & Submit Appendix 14, Section A
☐ No

81. Does this research study involve a device?

☐ Yes → Go to Question 82
☐ No → Skip to Question 83

82. Does the device meet the FDA's definition of a medical device?

☐ Yes → Complete & Submit Appendix 14, Section C
☐ No → Go to Question 83

FDA's Definition of a Medical Device: If a product is labeled, promoted or used in a manner that meets the following definition in section 201(h) of the Federal Food Drug and Cosmetic (FD&C) Act it will be regulated by the Food and Drug Administration (FDA) as a medical device and is subject to pre-marketing and post-marketing regulatory controls. A device is:

- an instrument, apparatus, implement, machine, contrivance, implant, in vitro reagent, or other similar or related article, including a component part, or accessory which is:
  - Recognized in the official National Formulary, or the United States Pharmacopoeia, or any supplement to them,
  - Intended for use in the diagnosis of disease or other conditions, or in the cure, mitigation, treatment, or prevention of disease, in man or other animals, or
  - Intended to affect the structure or any function of the body of man or other animals, and which does not achieve any of its primary intended purposes through chemical action within or on the body of man or other animals and which is not dependent upon being metabolized for the achievement of any of its primary intended purposes.

U. Biological Specimens

83. Will biological specimens (including blood, urine and other human-derived samples) be used in this study?

☐ Yes → Complete & Submit Appendix 18
☐ No

This form is available electronically at http://www.research.ou.edu/instare/human/apply/login/index.jsp
V. Other Biomedical Procedures – Diagnostic Radiation Procedures, Physical Activity, Diet Modifications

84. Will participants be asked to undergo diagnostic radiation procedures while enrolled in this study?
   ☐ Yes → Complete & Submit Appendix 16
   ☐ No

85. Will participants be required to engage in or perform any form of physical activity?
   ☐ Yes → Describe the nature and extent of the physical activity: operating a standard computer interface
   ☐ No

86. Will any type of electrical equipment other than audio headphones be attached to the participants (e.g., EMG, EKG)?
   ☐ Yes → Submit a letter describing the most recent safety check of the equipment with the supporting documents for this application.
   ☐ No

87. Will there be any diet modifications or restrictions?
   ☐ Yes → Describe:
   ☐ No

W. Assurances

As the principal investigator on this research study, I assure that...

1. this application, if funded by an extramural source, accurately reflects all procedures involving human participants described in the grant proposal to the funding agency previously noted or an explanation is given for any differences.

2. I will obtain approval from the Institutional Review Board (IRB) before initiating any changes to the approved study, including changes in procedures, personnel, documents, instruments, etc., except where necessary to eliminate apparent immediate hazards to participants. In the latter instance, the IRB must be notified by the next workday.

3. I am familiar with and will comply with all pertinent institutional, local, state, and Federal regulations and policies. I will adhere to the policies and procedures described in Penn State’s Federally Assured with the Office for Human Research Protections as well as Federal regulations for the protection of human participants involved in research (45CFR46, 21CFR parts 50 & 56). Copies of these documents are available in the ORP upon request or on their website – http://www.research.psu.edu/orp/.

4. the information provided in this application reasonably summarizes the nature and extent of the proposed use of human participants.

5. I will notify the IRB within 5 business days regarding any significant adverse events that impact human participants.

6. all individuals listed on this form are competent and have been properly trained. I also assure that all individuals will complete the required training for the protection of human participants available on-line prior to contact with human participants.

7. any individual associated with or responsible for the design, conduct, or the reporting of this research will comply with Penn State’s Conflict of Interest Policy, RA-65.

________________________________________________________    __________________________
Signature of Principal Investigator, REQUIRED                           Date

I hereby confirm that I have read this application and my signature denotes the completeness and accuracy of the information provided.

This form is available electronically at http://www.research.psu.edu/orp/humanapplications/index.asp
I hereby confirm that I have read this application and my signature denotes departmental/unit approval of this project. To the best of my knowledge, the information in the attached application relating to members of my department is correct.

The investigator(s) who are members of my department are qualified to perform the roles proposed for them in this application. Any novice researchers from my department will be supervised by qualified investigators.
APPENDIX 9
WAIVERS OF INFORMED CONSENT

Form Instructions:
- To complete the form, press TAB or SHIFT TAB between boxes and enter an ‘X’ or text. For assistance, contact the Office for Research Protections.
- Handwritten applications will NOT be accepted.

Project Title:
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness

Principal Investigator: Arthur C. Jones
PSU User ID (e.g., abcd123): acj100
Email Address: ajones@ist.psu.edu

A. Waiver of Documentation of Informed Consent – Complete if “Implied consent” or “Verbal consent” is checked in Question 43 of the Application for the Use of Human Participants

NOTE: A waiver of documentation of informed consent occurs when you are obtaining informed consent but participants are not required to sign the consent form (e.g., implied consent, verbal consent). The act of their completing and submitting the survey/interview would be considered their implied consent to participate.

1. One of the following two conditions must be met to allow for a process other than signed informed consent to be utilized. Choose which condition is applicable:
   - [ ] The only record linking the participant and the research would be the informed consent form. The principal risk to the participant is the potential harm resulting from a breach of confidentiality. Each participant will be asked whether he/she wants documentation linking the participant with the research and the participants wishes will govern. → Explain how your study fits into the category.
   - [x] The research presents no more than minimal risk of harm to participants & involves no procedures for which signed consent is normally required outside of the research context. → Explain how your study fits into the category. There is minimal risk to participants; Participation will be comparable to a minimally - non-violent - computer game.

B. Waiver of Informed Consent – Complete if “Passive/Opt out consent” is checked in Question 43 of the Application for the Use of Human Participants

NOTE: A waiver of informed consent means that the IRB is not requiring the principal investigator to obtain informed consent (i.e., the participants are sent a letter and are not required to act unless they do NOT wish to participate in the study OR the investigator is not required to obtain consent from participants) OR a consent procedure which does not include or which alters some or all of the required elements of consent.

1. Explain why a waiver of informed consent is being requested.

2. Describe how this study meets all four of the following conditions:
   - The research involves no more than minimal risk to the participants. → Explain how your study meets this criteria:
   - The waiver will not adversely affect the rights and welfare of participants. → Explain how your study meets this criteria:
   - The research could not practically be carried out without the waiver. → Explain how your study meets this criteria:
   - Will participants be provided with additional pertinent information after participation?
APPENDIX 11
USE OF COMPUTER AND/OR INTERNET IN RESEARCH

Form Instructions:
- To complete the form, press TAB or SHIFT TAB between boxes and enter an 'X' or text. For assistance, contact the Office for Research Protections.
- Handwritten applications will NOT be accepted.

Project Title:
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness

Principal Investigator: Arthur C. Jones
PSU User ID (e.g., abc123): acj100
Email Address: arokes@ist.psu.edu

A. Complete this Appendix if the response to Question 55 in the Application for the Use of Human Participants is YES.
1. Is there a method in place to authenticate the identity of participants?
   - Yes ☑️ ← Describe the authentication method: authentication is not needed as participants will be anonymous
   - No ☒️ ← Explain why an authentication method is not in place:

2. Will data be sent in an encrypted format?
   - Yes ☑️ ← Describe the level of encryption:
   - No ☒️ ← Explain why data will not be sent in an encrypted format: no personally identifying data will be collected; the data transmitted over the internet will be encoded and not useful without the index key

B. Complete this Appendix if the response to Question 56 in the Application for the Use of Human Participants is YES.
3. Identify the commercial service provider who will collect and/or store the data.

4. Describe the confidentiality policies and procedures of the commercial service provider. If policies & procedures are attached, indicate such.

5. Is access to the data maintained on the server limited to the principal investigator?
   - Yes ☑️
   - No ☒️ ← Who will have access to the server?

6. Are there frequent, regularly scheduled security audits of the server?
   - Yes ☑️ ← Describe the frequency of the audits:
   - No ☒️ ← Explain why there are no security audits:
IRB Application Attachment: Contact Messages

Contact message / script for soliciting participants for study

As part of my work toward a Ph.D. degree through Penn State’s College of Information Sciences and Technology, I am conducting an experiment to study the speed and accuracy of people as they interpret audio messages and build mental models of the situation being described. The experiment is based upon the activities that occur in 911 communications centers. This study is being conducted for research purposes, and research participants are being sought. Anyone able to use a typical personal computer and web browser may participate.

The entire process should take 20-30 minutes of your time, and will be run entirely through a web browser. In exchange for your participation, you will be offered the opportunity to be included in a random drawing for a gift certificate.

If you are willing to participate (or you would like to know a bit more before committing), please click here [linked text] or paste the following address into a web browser: [web address is yet to be defined]

For additional information, or to express any concerns, please contact:
Art Jones
118B Keller Building
University Park, PA. 16802
e-mail: ajones@ist.psu.edu

Website greeting

Welcome and thank you for visiting my "user interface experiment" web page. This study is being conducted for research purposes, and research participants are being sought. Anyone able to use a typical personal computer and web browser may participate.

I am working toward a Ph.D. in Information Sciences and Technology at the Pennsylvania State University. This web application is the data-gathering component of an experiment I am conducting as a part of that effort. I very much appreciate your time, and I have arranged for a set of drawings to be held, awarding gift certificates, to randomly-selected participants who complete the experiment. Here is what is involved:

The next page will apprise you of your rights as a participant in this study, and allow you to gracefully decline to participate. If you continue (please do), the following page will provide some more details and gather preliminary information from you. You will then be taken to a web page which you will use to record activity into a database. The activities I will ask you to record will come as audio messages which will start out slow and then get faster and faster. The messages will describe the simulated activity of emergency resources (police, fire, and medical)
in a fictional city. I am interested in the speed and accuracy of your understanding the audio messages. The entire process should take about twenty minutes.

Once you have completed the experiment, you will be shown a score and ranking, so you can get an idea of how well you did compared to others who have participated. At this point, you will have the option to submit an e-mail address which will be entered into a couple of random drawings for prizes to be held at the conclusion of the study. If you submit an e-mail address, it will be included in a drawing from all submissions. In addition, if your score is in the top 25% of all of the scores, the submitted e-mail address will be included in a separate drawing for another prize. Prizes will be gift certificates for a variety of businesses, ranging in values from $10 to $50. (Please note: The e-mail address you supply and the score you achieve will not be correlated with any other data you provide through the course of the experiment.)

If you have any questions or concerns regarding this research, please contact:
Art Jones
118B Keller Building
University Park, PA 16802
e-mail: ajones@ist.psu.edu

Informed consent

**Title of Project:**
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness

This research project is in partial fulfillment of the requirements for a Ph.D. degree through The Pennsylvania State University’s College of Information Sciences and Technology

This study is being conducted for research purposes.

**Primary Investigator:**
Arthur C. Jones, MS, EMT-P, Ph.D. Candidate
College of Information Sciences and Technology – The Pennsylvania State University
118-B Keller Building; University Park, PA. 16802
e-mail: ajones@ist.psu.edu
phone: 814-386-3808

**Other Investigator(s):**
Dr. Michael D. McNeese, Ph.D. (faculty advisor / committee chair)
College of Information Sciences and Technology - The Pennsylvania State University
325-A IST Building; University Park, PA. 16802
e-mail: mmcneese@ist.psu.edu
phone: 814-865-7885
**Purpose:**
The study will quantitatively assess the ability of subjects to interpret audio messages and record those interpretations into a database via a variety of interface designs, while simultaneously formulating situational awareness of the dynamic environment reported by the messages.

**Potential Benefits:**
These functions being studied are derived from the activities of emergency operations center personnel, who may benefit by improved information management techniques resulting from this study.

**Procedures:**
You will be lead through the collection of some basic demographic information, any piece of which you may refuse to answer without penalty. You will then be taken to a web page which you will use to record activity into a database. The activities you will be asked to record will come as audio messages which will start out slow and then get faster and faster. The messages will describe the simulated activity of emergency resources (police, fire, and medical) in a fictional city. The speed and accuracy of your submissions will be recorded for analysis. At random times, the simulation will freeze and you will be asked to supply some information designed to test your understanding of the simulated situation. There are no risks or discomforts foreseen in the procedures of this study.

**Compensation:**
At the conclusion of your session, you will have the option to submit an e-mail address which will be entered into a set of random drawings for gift certificates to be held at the conclusion of the study. There will be two distinct drawings, each with three winners of equal value. The first drawing will be inclusive of all participants who complete the study, and elect to submit an e-mail address for inclusion in the drawings. The second, “bonus drawing”, will be inclusive of all participants who score at or above the 75th percentile of all participants, and who elect to submit an e-mail address for inclusion in the drawings. Please be aware that total payments within one calendar year that exceed $600 will require the University to report these payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income.

**Time Requirements:**
Complete participation in a session will take approximately 20-30 minutes

**Confidentiality:**
Your confidentiality will be kept to the degree permitted by the technology being used. No guarantees can be made regarding the interception of data sent via the Internet by any third parties. No personally identifiable information will be collected. The data collected will be confidential and stored in a secure database. In the event of any publication or presentation resulting from this research, no personally identifiable information will be disclosed. E-mail
addresses collected for inclusion in the drawings for prizes at the conclusion of this study will be
held distinctly from the other collected data, and will used only for the specified purpose.
Addresses will not be shared with any person or organization besides the P.I., and will be
deleted following the prize drawings.

**Participation:**
Participation is voluntary. Participants may refuse to answer any question and may
withdraw their participation at any time. (This may be done my simply ceasing to respond to
the experiment’s stimuli and/or closing the browser session.)

You must be at least 18 years of age to participate in this study.

**Questions:**
Participants have the right to ask questions and have those questions answered. Any
questions regarding this research may be directed to the primary investigator named above. If
you have questions about your rights as a research participant, contact Penn State’s Office for
Research Protections at 814-865-1775. If you feel you have been harmed in any way by your
participation in this study, please contact either the P.I. named above or Penn State’s Office for
Research Protections.

**Acknowledgement:**
By clicking on the “I Agree” button below, you acknowledge that you have read and
understand all of the points listed on this page. You are encouraged to print this page for your
own records.

**Demographics Questions**

*Questions determining inclusion in the analysis phase:*
- What is your age?
- Do you have any uncorrected hearing problems?
- Do you have any uncorrected vision problems?
- Do you have any mobility problems affecting your ability to operate a standard
  computer interface?
- Do you have any prior work experience in 9-1-1 or other command-and-control
  facilities?

*Potential covariant measures:*
- What is your semester standing?
- What is your major?
- What is your GPA?
- How much time do you spend working on a computer each day, on average?
- How much time do you spend playing computer games each day, on average?
APPENDIX F – APPARATUS SQL & PHP SOURCE CODE

SQL code for MySQL database definition

--
-- Create schema experiment
--

CREATE DATABASE IF NOT EXISTS experiment;
USE experiment;

-- Definition of table 'demographics'
--

DROP TABLE IF EXISTS `demographics`;
CREATE TABLE `demographics` ( 
  `session_id` int(10) unsigned NOT NULL,
  `age_cat` int(10) unsigned DEFAULT NULL,
  `gender` int(10) unsigned DEFAULT NULL,
  `hearing_problems` int(10) unsigned DEFAULT NULL,
  `vision_problems` int(10) unsigned DEFAULT NULL,
  `movement_problems` int(10) unsigned DEFAULT NULL,
  `prior_experience` int(10) unsigned DEFAULT NULL,
  `computer_time` int(10) unsigned DEFAULT NULL,
  `video_games` int(10) unsigned DEFAULT NULL,
  `student_semester` int(10) unsigned DEFAULT NULL,
  `student_gpa` int(10) unsigned DEFAULT NULL,
  `student_major` int(10) unsigned DEFAULT NULL,
  `CogStyle_Q1` int(11) DEFAULT NULL,
  `CogStyle_Q2` int(11) DEFAULT NULL,
  `CogStyle_Q3` int(11) DEFAULT NULL,
  `CogStyle_Q4` int(11) DEFAULT NULL,
  `CogStyle_Q5` int(11) DEFAULT NULL,
  `CogStyle_Q6` int(11) DEFAULT NULL,
  `CogStyle_Q7` int(11) DEFAULT NULL,
  `CogStyle_Q8` int(11) DEFAULT NULL,
  `CogStyle_Q9` int(11) DEFAULT NULL,
  `CogStyle_Q10` int(11) DEFAULT NULL,
  `CogStyle_Q11` int(11) DEFAULT NULL,
  `CogStyle_Q12` int(11) DEFAULT NULL,
  `CogStyle_Q13` int(11) DEFAULT NULL,
  `CogStyle_Q14` int(11) DEFAULT NULL,
  `CogStyle_Q15` int(11) DEFAULT NULL,
  `CogStyle_Q16` int(11) DEFAULT NULL,
  `CogStyle_Q17` int(11) DEFAULT NULL,
  `CogStyle_Q18` int(11) DEFAULT NULL,
  `CogStyle_Q19` int(11) DEFAULT NULL,
  `CogStyle_Q20` int(11) DEFAULT NULL,
  `CogStyle_Q21` int(11) DEFAULT NULL,
  `CogStyle_Score` int(11) DEFAULT NULL,
  PRIMARY KEY (`session_id`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

--
-- Definition of table 'drawing_participants'
--
DROP TABLE IF EXISTS `drawing_participants`;
CREATE TABLE `drawing_participants` (    `id` int(10) unsigned NOT NULL AUTO_INCREMENT,
    `submit_time` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,
    `name` varchar(50) DEFAULT NULL,
    `email` varchar(50) DEFAULT NULL,
    `score` int(10) unsigned DEFAULT NULL,
    PRIMARY KEY (`id`)
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

-- Definition of table `incident_types`

DROP TABLE IF EXISTS `incident_types`;
CREATE TABLE `incident_types` (    `incident_type_id` int(10) unsigned NOT NULL AUTO_INCREMENT,
    `incident_type_description` varchar(45) NOT NULL,
    PRIMARY KEY (`incident_type_id`)
) ENGINE=InnoDB AUTO_INCREMENT=8 DEFAULT CHARSET=latin1;

-- Dumping data for table `incident_types`

INSERT INTO `incident_types` VALUES  (1,'accident'),
  (2,'chemical spill'),
  (3,'fight'),
  (4,'robbery'),
  (5,'fire'),
  (6,'fallen tree'),
  (7,'medical emergency');

-- Definition of table `locations`

DROP TABLE IF EXISTS `locations`;
CREATE TABLE `locations` (    `location_id` int(10) unsigned NOT NULL AUTO_INCREMENT,
    `location_description` varchar(45) NOT NULL,
    PRIMARY KEY (`location_id`)
) ENGINE=InnoDB AUTO_INCREMENT=6 DEFAULT CHARSET=latin1;

-- Dumping data for table `locations`

INSERT INTO `locations` VALUES  (1,'Franklin'),
  (2,'Salem'),
  (3,'Washington'),
  (4,'Springfield'),
  (5,'Clinton');

-- Definition of table `logs`
DROP TABLE IF EXISTS `logs`;
CREATE TABLE `logs` (  
    `log_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
    `submit_time` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,  
    `log_text` text,  
    PRIMARY KEY (`log_id`)  
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

--
-- Definition of table `reported_changes`
--

DROP TABLE IF EXISTS `reported_changes`;
CREATE TABLE `reported_changes` (  
    `report_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
    `session_id` int(10) unsigned NOT NULL,  
    `report_time` int(10) unsigned NOT NULL,  
    `incident_type` int(10) unsigned DEFAULT NULL,  
    `incident_location` int(10) unsigned DEFAULT NULL,  
    `resource` int(10) unsigned DEFAULT NULL,  
    `new_status` int(10) unsigned DEFAULT NULL,  
    `time_since_last_announcement` int(10) unsigned DEFAULT NULL,  
    `time_since_last_report` int(10) unsigned DEFAULT NULL,  
    PRIMARY KEY (`report_id`)  
) ENGINE=InnoDB DEFAULT CHARSET=latin1;

--
-- Definition of table `resource_types`
--

DROP TABLE IF EXISTS `resource_types`;
CREATE TABLE `resource_types` (  
    `resource_type_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
    `resource_type_description` varchar(45) NOT NULL,  
    PRIMARY KEY (`resource_type_id`)  
) ENGINE=InnoDB AUTO_INCREMENT=4 DEFAULT CHARSET=latin1;

-- Dumping data for table `resource_types`

INSERT INTO `resource_types` VALUES  
(1,'police'),  
(2,'fire'),  
(3,'EMS');

--
-- Definition of table `resources`
--

DROP TABLE IF EXISTS `resources`;
CREATE TABLE `resources` (  
    `resource_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
    `resource_type` int(10) unsigned NOT NULL,  
    `resource_base_location` int(10) unsigned NOT NULL,  
    `resource_name` varchar(45) NOT NULL,  
    PRIMARY KEY (`resource_id`),  
    KEY `FK_resources_1` (`resource_type`),  
    KEY `FK_resources_2` (`resource_base_location`),  
    PRIMARY KEY (`resource_id`)  
) ENGINE=InnoDB
CONSTRAINT `FK_resources_1` FOREIGN KEY (`resource_type`) REFERENCES `resource_types` (`resource_type_id`),
CONSTRAINT `FK_resources_2` FOREIGN KEY (`resource_base_location`) REFERENCES `locations` (`location_id`)
) ENGINE=InnoDB AUTO_INCREMENT=41 DEFAULT CHARSET=latin1;

--
-- Dumping data for table `resources`
--

INSERT INTO `resources` VALUES
(1,1,1,'one'),
(2,1,1,'two'),
(3,1,1,'three'),
(4,1,1,'four'),
(5,1,2,'five'),
(6,1,2,'six'),
(7,1,2,'seven'),
(8,1,2,'eight'),
(9,1,3,'nine'),
(10,1,3,'ten'),
(11,1,3,'eleven'),
(12,1,3,'twelve'),
(13,1,4,'thirteen'),
(14,1,4,'fourteen'),
(15,1,4,'fifteen'),
(16,1,4,'sixteen'),
(17,1,5,'seventeen'),
(18,1,5,'eighteen'),
(19,1,5,'nineteen'),
(20,1,5,'twenty'),
(21,2,1,'one'),
(22,2,1,'two'),
(23,2,2,'three'),
(24,2,2,'four'),
(25,2,3,'five'),
(26,2,3,'six'),
(27,2,4,'seven'),
(28,2,4,'eight'),
(29,2,5,'nine'),
(30,2,5,'ten'),
(31,3,1,'one'),
(32,3,1,'two'),
(33,3,2,'three'),
(34,3,2,'four'),
(35,3,3,'five'),
(36,3,3,'six'),
(37,3,4,'seven'),
(38,3,4,'eight'),
(39,3,5,'nine'),
(40,3,5,'ten');

--
-- Definition of table `sagat_responses`
--

DROP TABLE IF EXISTS `sagat_responses`;
CREATE TABLE `sagat_responses` (  
sagat_response_id int(10) unsigned NOT NULL AUTO_INCREMENT,  
session_id int(10) unsigned NOT NULL,  
script int(10) unsigned DEFAULT NULL,  
);
`message` int(10) unsigned DEFAULT NULL,
`CT1` int(10) unsigned DEFAULT NULL,
`CT2` int(10) unsigned DEFAULT NULL,
`CT3` int(10) unsigned DEFAULT NULL,
`CT4` int(10) unsigned DEFAULT NULL,
`CT5` int(10) unsigned DEFAULT NULL,
`CT6` int(10) unsigned DEFAULT NULL,
`CT7` int(10) unsigned DEFAULT NULL,
`MFT` int(10) unsigned DEFAULT NULL,
`LFT` int(10) unsigned DEFAULT NULL,
`CPI` int(10) unsigned DEFAULT NULL,
`CFI` int(10) unsigned DEFAULT NULL,
`CM1` int(10) unsigned DEFAULT NULL,
`BSC` int(10) unsigned DEFAULT NULL,
`BSO` int(10) unsigned DEFAULT NULL,
`CL1` int(10) unsigned DEFAULT NULL,
`CL2` int(10) unsigned DEFAULT NULL,
`CL3` int(10) unsigned DEFAULT NULL,
`CL4` int(10) unsigned DEFAULT NULL,
`CL5` int(10) unsigned DEFAULT NULL,
`BLC` int(10) unsigned DEFAULT NULL,
`CIC` int(10) unsigned DEFAULT NULL,
`TIC` int(10) unsigned DEFAULT NULL,

PRIMARY KEY (`sagat_response_id`) USING BTREE
) ENGINE=InnoDB AUTO_INCREMENT=4 DEFAULT CHARSET=latin1;

--
-- Definition of table `scripts`
--

DROP TABLE IF EXISTS `scripts`;
CREATE TABLE `scripts` (
  `script_element_id` int(10) unsigned NOT NULL AUTO_INCREMENT,
  `script_id` int(10) unsigned NOT NULL,
  `script_time` int(10) unsigned NOT NULL,
  `incident_number` int(10) unsigned DEFAULT NULL,
  `incident_type` int(10) unsigned DEFAULT NULL,
  `incident_location` int(10) unsigned DEFAULT NULL,
  `resource_type` int(10) unsigned DEFAULT NULL,
  `resource_id` char(10) DEFAULT NULL,
  `new_status` int(10) unsigned DEFAULT NULL,
  `message_text` varchar(200) NOT NULL,
  `message_filename` varchar(25) DEFAULT NULL,
  `tts_command` varchar(200) DEFAULT NULL,
  `total_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_incidents` int(10) unsigned DEFAULT NULL,
  `type_1_incident_total` int(10) unsigned DEFAULT NULL,
  `type_2_incident_total` int(10) unsigned DEFAULT NULL,
  `type_3_incident_total` int(10) unsigned DEFAULT NULL,
  `type_4_incident_total` int(10) unsigned DEFAULT NULL,
  `type_5_incident_total` int(10) unsigned DEFAULT NULL,
  `type_6_incident_total` int(10) unsigned DEFAULT NULL,
  `type_7_incident_total` int(10) unsigned DEFAULT NULL,
  `concurrent_type_1_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_2_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_3_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_4_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_5_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_6_incidents` int(10) unsigned DEFAULT NULL,
  `concurrent_type_7_incidents` int(10) unsigned DEFAULT NULL,
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</tr>
</thead>
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</tr>
<tr>
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<td>null</td>
</tr>
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<td>unsigned</td>
<td>null</td>
</tr>
<tr>
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</tr>
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<tr>
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<tr>
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<td>null</td>
</tr>
<tr>
<td>fire_assignments_total</td>
<td>int(10)</td>
<td>unsigned</td>
<td>null</td>
</tr>
<tr>
<td>medical_assignments_total</td>
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<td>null</td>
</tr>
<tr>
<td>concurrent_fire_assignments</td>
<td>int(10)</td>
<td>unsigned</td>
<td>null</td>
</tr>
<tr>
<td>concurrent_medical_assignments</td>
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</tr>
<tr>
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<td></td>
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</tbody>
</table>

-- Dumping data for table `scripts`
```

```
\r
-- Dumping data for table `scripts`\r
\r
INSERT INTO `scripts` VALUES (2962,1,10,1,1,2,0,'','','There is a new accident incident in the Salem neighborhood.','1_1.mp3', 'echo "There is a new accident incident in the Salem neighborhood." | text2wave | lame - 1_1.mp3 ;',1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,1,0,0,0,NULL,0,1,0,0,0,NULL,0,0,0,0,0,0,0,0,0),
(2963,1,21,1,1,2,1,'five',1,'Police car number five has been dispatched to the accident in Salem.','1_2.mp3', 'echo "Police car number five has been dispatched to the accident in Salem." | text2wave | lame - 1_2.mp3 ;',1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,1,0,0,0,NULL,0,1,0,0,0,NULL,0,0,0,0,0,0,0,0,0),
(2964,1,31,1,1,2,3,'three',1,'Medical transport number three has been dispatched to the accident in Salem.','1_3.mp3', 'echo "Medical transport number three has been dispatched to the accident in Salem." | text2wave | lame - 1_3.mp3 ;',1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,1,0,0,0,NULL,0,1,0,0,0,NULL,0,0,0,0,0,0,0,0,0),
(2965,1,40,1,1,2,2,'four',1,'Fire engine number four has been dispatched to the accident in Salem.','1_4.mp3', 'echo "Fire engine number four has been dispatched to the accident in Salem." | text2wave | lame - 1_4.mp3 ;',1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,1,0,0,0,NULL,0,1,0,0,0,NULL,0,0,0,0,0,0,0,0,0),
(2966,1,49,1,1,2,3,'three',2,'Ambulance number three is enroute.','1_5.mp3', 'echo "Ambulance number three is enroute." | text2wave | lame - 1_5.mp3 ;',1,1,0,0,0,0,0,0,1,0,0,0,0,0,0,0,0,1,0,0,0,NULL,0,1,0,0,0,NULL,0,0,0,0,0,0,0,0,0),
(2967,1,58,1,1,2,1,'five',2,'Police car number five is enroute.','1_6.mp3', 'echo "Police car number five is enroute." | text2wave
```

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Fire engine number four is enroute.

There is a new spill incident in the Clinton neighborhood.

Fire engine number nine has been dispatched to the spill in Clinton.

Police unit number seventeen has been dispatched to the spill in Clinton.

Police unit number five is on scene.

Ambulance number three is on scene.

There is a new accident incident in the Salem zone.

Police unit number six has been dispatched to the accident in Salem.

Fire unit number three has been dispatched to the accident in Salem.
Medical transport number four has been dispatched to the accident in Salem.

Police unit number six is enroute.

Medical unit number four is enroute.

Police car number seventeen is on scene.

Fire engine number three is enroute.

Fire engine number four is on scene.

Fire truck number seven has been dispatched to the fire in Salem.

Ambulance number one has been dispatched to the fire in Salem.

Police unit number six is on scene.

Medical unit number one is enroute.

Fire truck number seven is enroute.

Fire truck number seven is on scene.

Medical unit number one is enroute.

Fire truck number seven is on scene.
(2991,1,297,2,5,2,'nine',3,'Fire engine number nine is on scene.','1_30.mp3','echo "Fire engine number nine is on scene." | text2wave | lame - 1_30.mp3
;','4,4,2,1,0,0,1,0,0,2,1,0,0,1,0,0,3,0,0,1,0,0,0,1,NULL,0,3,0,0,1,NULL,3,4,3,3,4,3,0.444444444444444),
(2992,1,306,3,1,2,3,'four',3,'Medical unit number four is on scene.','1_31.mp3','echo "Medical unit number four is on scene." | text2wave | lame - 1_31.mp3
;','4,4,2,1,0,0,1,0,0,2,1,0,0,1,0,0,3,0,0,1,0,0,0,1,NULL,0,3,0,0,1,NULL,3,4,3,3,4,3,0.4),
(2993,1,316,5,3,2,0,'',0,'There is a new fight incident in the Salem area.'\"1_32.mp3\"','echo \"There is a new fight incident in the Salem area.\" | text2wave | lame - 1_32.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,3,4,3,3,4,3,0.5),
(2994,1,325,5,3,2,1,'seven',1,'Polie unit number seven has been dispatched to the fight in Salem.'\"1_33.mp3\"','echo \"Police unit number seven has been dispatched to the fight in Salem.\" | text2wave | lame - 1_33.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,4,4,3,4,4,3,0.555555555555556),
(2995,1,334,5,3,2,3,'six',1,'Medical transport number six has been dispatched to the fight in Salem.'\"1_34.mp3\"','echo \"Medical transport number six has been dispatched to the fight in Salem.\" | text2wave | lame - 1_34.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,4,4,4,4,4,4,0.555555555555556),
(2996,1,342,5,3,2,1,'seven',2,'Police car number seven is enroute.'\"1_35.mp3\"','echo \"Police car number seven is enroute.\" | text2wave | lame - 1_35.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,4,4,4,4,4,4,0.625),
(2997,1,350,5,3,2,3,'six',2,'Ambulance number six is enroute.'\"1_36.mp3\"','echo \"Ambulance number six is enroute.\" | text2wave | lame - 1_36.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,4,4,4,4,4,4,0.625),
(2998,1,358,5,3,2,2,'three',3,'Fire engine number three is on scene.'\"1_37.mp3\"','echo \"Fire engine number three is on scene.\" | text2wave | lame - 1_37.mp3
;','5,5,2,1,1,0,1,0,0,2,1,1,0,1,0,0,0,4,0,0,1,NULL,0,4,0,0,1,NULL,4,4,4,4,4,4,0.625),
(2999,1,363,6,2,1,0,'',0,'There is a new spill incident in the Franklin zone.'\"1_38.mp3\"','echo \"There is a new spill incident in the Franklin zone.\" | text2wave | lame - 1_38.mp3
;','6,6,2,2,1,0,1,0,0,2,2,1,0,1,0,0,0,1,4,0,0,1,NULL,1,4,0,0,1,NULL,4,4,4,4,4,4,1.2),
(3000,1,368,4,5,2,3,'one',3,'Ambulance number one is on scene.'\"1_39.mp3\"','echo \"Ambulance number one is on scene.\" | text2wave | lame - 1_39.mp3
;','6,6,2,2,1,0,1,0,0,2,2,1,0,1,0,0,1,4,0,0,1,NULL,1,4,0,0,1,NULL,4,4,4,4,4,4,1.2),
(3001,1,373,6,2,1,2,'one',1,'Fire truck number one has been dispatched to the spill in Franklin.'\"1_40.mp3\",'echo \"Fire truck number one has been dispatched to the spill in Franklin.\" | text2wave | lame - 1_40.mp3
;','6,6,2,2,1,0,1,0,0,2,2,1,0,1,0,0,1,4,0,0,1,NULL,1,4,0,0,1,NULL,4,5,4,4,5,4,1.2),
Police car number four has been dispatched to the spill in Franklin.

Police unit number four is enroute.

Police unit number seven is on scene.

Fire truck number one is enroute.

Fire engine number seven is on scene.

There is a new fight incident in the Washington region.

Police unit number ten has been dispatched to the fight in Washington.

Medical unit number five has been dispatched to the fight in Washington.

Medical transport number six is on scene.

Police unit number ten is enroute.

Medical transport number five is enroute.

Police car number four is on scene.
There is a new fight incident in the Franklin region.  
Police unit number five is available.  
Medical transport number two has been dispatched to the fight in Franklin.  
Police car number two has been dispatched to the fight in Franklin.  
Medical transport number five is on scene.  
Police car number ten is on scene.  
Fire truck number one is on scene.  
Medical transport number five is on scene.  
Police car number seventeen is available.  
There is a new medical incident in the Springfield zone.
Ambulance number seven has been dispatched to the medical in Springfield.

Police car number seventeen is back at base.

Police car number two is on scene.

Medical unit number seven is enroute.

Medical unit number three is available.

Police car number six is available.

Police car number six is back at base.

Ambulance number two is on scene.

Fire engine number one has been dispatched to the accident in Franklin.

Police unit number three has been dispatched to the accident in Franklin.

Medical unit number one has been dispatched to the accident in Franklin.

Fire engine number one has been dispatched to the accident in Franklin.
dispatched to the accident in Franklin.

There is a new robbery incident in the Franklin zone.

There is a new robbery incident in the Franklin zone.

There is a new accident incident in the Washington region.

There is a new accident incident in the Washington region.

There is a new accident incident in the Washington region.

There is a new accident incident in the Washington region.

There is a new accident incident in the Washington region.

There is a new accident incident in the Washington region.
(3049,2,159,3,1,3,3,'five',1,'Medical transport number five has been
dispatched to the accident in Washington.','2_16.mp3','echo "Medical
transport number five has been dispatched to the accident in Washington." | text2wave | lame - 2_16.mp3

(3050,2,168,2,4,1,1,'four',3,'Police car number four is on
scene.','2_17.mp3','echo "Police car number four is on scene." | text2wave
| lame - 2_17.mp3

(3051,2,178,3,1,3,1,'eleven',2,'Police unit number eleven is
enroute.','2_18.mp3','echo "Police unit number eleven is enroute." | text2wave
| lame - 2_18.mp3

(3052,2,189,1,1,1,2,'one',3,'Fire truck number one is on
scene.','2_19.mp3','echo "Fire truck number one is on scene." | text2wave
| lame - 2_19.mp3

(3053,2,198,3,1,3,3,'five',2,'Ambulance number five is
enroute.','2_20.mp3','echo "Ambulance number five is enroute." | text2wave
| lame - 2_20.mp3

(3054,2,209,3,1,3,2,'six',2,'Fire unit number six is
enroute.','2_21.mp3','echo "Fire unit number six is enroute." | text2wave
| lame - 2_21.mp3

(3055,2,218,4,4,3,0,'',0,'There is a new robbery incident in the Washington
area.','2_22.mp3','echo "There is a new robbery incident in the Washington
area." | text2wave | lame - 2_22.mp3

(3056,2,229,4,4,3,1,'nine',1,'Police car number nine has been dispatched to
the robbery in Washington.','2_23.mp3','echo "Police car number nine has
been dispatched to the robbery in Washington." | text2wave | lame - 2_23.mp3

(3057,2,240,4,4,3,1,'nine',2,'Police car number nine is
enroute.','2_24.mp3','echo "Police car number nine is enroute." | text2wave
| lame - 2_24.mp3

(3058,2,249,3,1,3,1,'eleven',3,'Police unit number eleven is on
scene.','2_25.mp3','echo "Police unit number eleven is on scene." | text2wave
| lame - 2_25.mp3

(3059,2,258,3,1,3,3,'five',3,'Ambulance number five is on
scene.','2_26.mp3','echo "Ambulance number five is on scene." | text2wave
| lame - 2_26.mp3

(3060,2,268,5,1,3,0,'',0,'There is a new accident incident in the
Washington neighborhood.','2_27.mp3','echo "There is a new accident incident in the Washington neighborhood." | text2wave | lame - 2_27.mp3
Police car number twelve has been dispatched to the accident in Washington.

Fire truck number five has been dispatched to the accident in Washington.

Medical unit number six has been dispatched to the accident in Washington.

Police unit number nine is on scene.

Police car number twelve is enroute.

Medical unit number six is enroute.

There is a new fight incident in the Springfield neighborhood.

Police unit number sixteen has been dispatched to the fight in Springfield.

Medical transport number seven has been dispatched to the fight in Springfield.
Police car number twelve is on scene.

Police car number sixteen is enroute.

Medical transport number seven is enroute.

Medical unit number six is on scene.

There is a new fire incident in the Springfield neighborhood.

Fire engine number seven has been dispatched to the fire in Springfield.

Ambulance number eight is enroute.

Fire truck number five is on scene.

Police car number sixteen is on scene.

Medical transport number seven is enroute.

Medical unit number six is on scene.

There is a new fire incident in the Springfield neighborhood.

Fire engine number seven has been dispatched to the fire in Springfield.

Ambulance number eight is enroute.

Fire truck number five is on scene.
Fire truck number seven is enroute.

Ambulance number seven is on scene.

There is a new fallen tree incident in the Clinton neighborhood.

Fire engine number ten has been dispatched to the fallen tree in Clinton.

There is a new fallen tree incident in the Salem zone.

Fire unit number three has been dispatched to the fallen tree in Salem.
Police car number eleven is available.

Police unit number eleven is back at base.

Fire engine number seven is on scene.

Fire engine number three is enroute.

There is a new robbery incident in the Washington zone.

Police car number eleven has been dispatched to the robbery in Washington.

Police car number nine is available.

Medical transport number one is back at base.

There is a new fire incident in the Clinton neighborhood.

Police unit number eleven is enroute.

Fire unit number ten is on scene.

There is a new fire incident in the Clinton neighborhood.
Ambulance number nine has been dispatched to the fire in Clinton.

Fire unit number ten has been dispatched to the fire in Clinton.

Medical unit number nine is enroute.

Fire engine number ten is enroute.

There is a new robbery incident in the Springfield area.

Police unit number thirteen has been dispatched to the robbery in Springfield.

Police car number thirteen is enroute.

Medical transport number nine is on scene.

There is a new robbery incident in the Salem zone.

Police unit number seven has been dispatched to the robbery in Salem.

Police unit number thirteen is on scene.

Police car number seven is enroute.
Fire truck number ten is on scene.

There is a new fight incident in the Clinton neighborhood.

Police unit number seventeen has been dispatched to the fight in Clinton.

Medical transport number ten has been dispatched to the fight in Clinton.

Police car number seventeen is enroute.

Medical unit number ten is enroute.

Police unit number seven is on scene.

There is a new fallen tree incident in the Clinton region.

Fire truck number nine has been dispatched to the fallen tree in Clinton.

Fire engine number nine is enroute.

Fire truck number nine has been dispatched to the fallen tree in Clinton.

Fire engine number nine is enroute.
Ambulance number ten is on scene.

There is a new fight incident in the Salem zone.

Ambulance number three has been dispatched to the fight in Salem.

Medical transport number three is enroute.

There is a new spill incident in the Salem neighborhood.

Police unit number five has been dispatched to the spill in Salem.

Police unit number five is on scene.

Fire engine number four is enroute.

Police car number eight is enroute.
Fire engine number nine is on scene.

Ambulance number three is on scene.

There is a new robbery incident in the Washington region.

Police car number nine has been dispatched to the robbery in Washington.

There is a new robbery incident in the Franklin neighborhood.

Police unit number three has been dispatched to the robbery in Franklin.

Police car number nine is on scene.

Police car number eight is on scene.

Police car number thirteen is back at base.

There is a new robbery incident in the Franklin neighborhood.

Police unit number three has been dispatched to the robbery in Franklin.

Police car number nine is on scene.

Police car number nine is enroute.

Police car number thirteen is available.

Police unit number thirteen is available.

There is a new robbery incident in the Franklin neighborhood.

There is a new robbery incident in the Washington region.

Police car number nine is enroute.

Police car number thirteen is back at base.

There is a new robbery incident in the Franklin neighborhood.

There is a new robbery incident in the Franklin neighborhood.
\[9,8,0,1,2,4,1,1,0,0,1,2,3,1,1,0,1,3,1,1,3,\text{NULL},1,3,1,0,3,\text{NULL},7,3,3,6,3,3,1.6,\]
\[(3154,3,418,1,5,5,3,\text{'nine'},4,\text{"Medical unit number nine is available."},3_{49}.mp3,\text{"echo "Medical unit number nine is available." | text2wave | lame - 3_{49}.mp3} \]
\[9,8,0,1,2,4,1,1,0,0,1,2,3,1,1,0,1,3,1,1,3,\text{NULL},1,3,1,0,3,\text{NULL},7,3,3,6,3,2,1.33333333333333,\]
\[(3155,3,422,3,4,2,1,\text{'seven'},4,\text{"Police unit number seven is available."},3_{50}.mp3,\text{"echo "Police unit number seven is available." | text2wave | lame - 3_{50}.mp3} \]
\[9,8,0,1,2,4,1,1,0,0,1,2,3,1,1,0,1,3,1,1,3,\text{NULL},1,3,1,0,3,\text{NULL},7,3,3,5,3,2,1\]
\[(3156,3,428,7,2,2,2,\text{'four'},3,\text{"Fire truck number four is on scene."},3_{51}.mp3,\text{"echo "Fire truck number four is on scene." | text2wave | lame - 3_{51}.mp3} \]
\[9,8,0,1,2,4,1,1,0,0,1,2,3,1,1,0,1,3,1,1,3,\text{NULL},1,3,1,0,3,\text{NULL},7,3,3,5,3,2,1.33333333333333,\]
\[(3157,3,432,3,4,2,1,\text{'seven'},0,\text{"Police car number seven is back at base."},3_{52}.mp3,\text{"echo "Police car number seven is back at base." | text2wave | lame - 3_{52}.mp3} \]
\[9,7,0,1,2,4,1,1,0,0,1,2,2,1,1,0,1,3,1,1,3,\text{NULL},1,2,1,0,3,\text{NULL},7,3,3,5,3,2,1.75,\]
\[(3158,3,436,10,7,4,0,'\text{'},0,\text{"There is a new medical incident in the Springfield zone."},3_{53}.mp3,\text{"echo "There is a new medical incident in the Springfield zone." | text2wave | lame - 3_{53}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,3,5,3,2,0,\]
\[(3159,3,440,10,7,4,3,'\text{eight}',1,\text{"Ambulance number eight has been dispatched to the medical in Springfield."},3_{54}.mp3,\text{"echo "Ambulance number eight has been dispatched to the medical in Springfield." | text2wave | lame - 3_{54}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,5,3,3,\]
\[(3160,3,444,4,3,5,1,\text{'seventeen'},4,\text{"Police unit number seventeen is available."},3_{55}.mp3,\text{"echo "Police unit number seventeen is available." | text2wave | lame - 3_{55}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,4,3,3,0,\]
\[(3161,3,448,10,7,4,3,\text{'eight'},2,\text{"Ambulance number eight is enroute."},3_{56}.mp3,\text{"echo "Ambulance number eight is enroute." | text2wave | lame - 3_{56}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,4,3,3,1.6,\]
\[(3162,3,452,9,4,1,1,\text{'three'},3,\text{"Police unit number three is on scene."},3_{57}.mp3,\text{"echo "Police unit number three is on scene." | text2wave | lame - 3_{57}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,4,3,3,0,\]
\[(3163,3,457,1,5,5,3,\text{'nine'},0,\text{"Ambulance number nine is back at base."},3_{58}.mp3,\text{"echo "Ambulance number nine is back at base." | text2wave | lame - 3_{58}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,4,3,3,1.6,\]
\[(3164,3,461,4,3,5,1,\text{'seventeen'},0,\text{"Police unit number seventeen is back at base."},3_{59}.mp3,\text{"echo "Police unit number seventeen is back at base." | text2wave | lame - 3_{59}.mp3} \]
\[10,8,0,1,2,4,1,1,1,0,1,2,2,1,1,1,1,3,1,2,3,\text{NULL},1,2,1,1,3,\text{NULL},7,3,4,4,3,3,0,\]
There is a new robbery incident in the Clinton area.

Police unit number nineteen has been dispatched to the robbery in Clinton.

Police unit number nineteen is enroute.

Fire unit number ten is available.

Medical transport number eight is on scene.

There is a new medical incident in the Springfield region.

Police unit number nineteen is on scene.

Fire engine number ten is back at base.

Ambulance number ten is available.

Police unit number five is available.

Medical transport number seven is enroute.

Police unit number five is available.

Medical transport number seven is enroute.
Police unit number five is back at base.

There is a new medical incident in the Salem neighborhood.

Ambulance number four has been dispatched to the medical in Salem.

Medical transport number four is enroute.

There is a new fire incident in the Franklin region.

Medical transport number one has been dispatched to the fire in Franklin.

Fire truck number one has been dispatched to the fire in Franklin.

Ambulance number one is enroute.

Fire unit number one is enroute.

Medical transport number four is on scene.

There is a new fallen tree incident in the Salem neighborhood.

Fire truck number four has been dispatched to the fallen tree in Salem.
dispatched to the fallen tree in Salem."

(3189,4,121,3,6,2,2,'four',2,'Fire engine number four is enroute.' | text2wave | lame - 4_11.mp3

';3,3,0,0,0,0,1,1,1,0,0,0,0,1,1,1,2,0,0,0,NUL,1,2,0,0,0,NUL,0,2,2,0,2,2,0,3),

(3190,4,131,2,5,1,3,'one',3,'Medical unit number one is on scene.' | text2wave | lame - 4_13.mp3

';3,3,0,0,0,0,1,1,1,0,0,0,0,1,1,1,2,0,0,0,NUL,1,2,0,0,0,NUL,0,2,2,0,2,2,0,3),

(3191,4,140,4,4,4,0','0,'There is a new robbery incident in the Springfield neighborhood.' | text2wave | lame - 4_14.mp3

';4,4,0,0,0,1,1,1,1,1,0,0,1,1,1,1,1,2,0,1,0,NUL,1,2,0,1,0,NUL,1,2,2,1,2,2,0,4),

(3192,4,151,4,4,4,1,'thirteen',1,'Police car number thirteen has been dispatched to the robbery in Springfield.' | text2wave | lame - 4_15.mp3

';4,4,0,0,0,1,1,1,1,1,0,0,1,1,1,1,1,2,0,1,0,NUL,1,2,0,1,0,NUL,1,2,2,1,2,2,0,4),

(3193,4,161,4,4,4,1,'thirteen',2,'Police unit number thirteen is enroute.' | text2wave | lame - 4_16.mp3

';4,4,0,0,0,1,1,1,1,1,0,0,0,1,1,1,1,1,2,0,1,0,NUL,1,2,0,1,0,NUL,1,2,2,1,2,2,0,4),

(3194,4,171,2,5,1,2,'one',3,'Fire truck number one is on scene.' | text2wave | lame - 4_17.mp3

';4,4,0,0,0,1,1,1,1,0,0,0,1,1,1,1,1,2,0,1,0,NUL,1,2,0,1,0,NUL,1,2,2,1,2,2,0,4),

(3195,4,180,5,6,3,0','0,'There is a new fallen tree incident in the Washington region.' | text2wave | lame - 4_18.mp3

';5,5,0,0,0,1,1,2,1,0,0,0,1,1,2,1,1,2,1,1,0,NUL,1,2,1,1,0,NUL,1,2,2,1,2,2,0,4),

(3196,4,191,3,6,3,2,'six',1,'Fire unit number six has been dispatched to the fallen tree in Washington.' | text2wave | lame - 4_19.mp3

';5,5,0,0,0,1,1,2,1,0,0,0,1,1,2,1,1,2,1,1,0,NUL,1,2,1,1,0,NUL,1,3,2,1,3,2,0,4),

(3197,4,202,4,4,4,1,'thirteen',3,'Police unit number thirteen is on scene.' | text2wave | lame - 4_20.mp3

';4,4,0,0,0,1,1,1,1,0,0,0,1,1,1,1,1,2,0,1,0,NUL,1,2,0,1,0,NUL,1,2,2,1,2,2,0,4),

(3198,4,211,5,6,3,2,'six',2,'Fire truck number six is enroute.' | text2wave | lame - 4_21.mp3

';5,5,0,0,0,1,1,2,1,0,0,0,1,1,2,1,1,2,1,1,0,NUL,1,2,1,1,0,NUL,1,3,2,1,3,2,0,4),

(3199,4,221,3,6,3,2,'four',3,'Fire unit number four is on scene.' | text2wave | lame - 4_22.mp3

';5,5,0,0,0,1,1,2,1,0,0,0,0,0,1,1,2,1,1,2,1,1,0,NUL,1,2,1,1,0,NUL,1,3,2,1,3,2,0,5),

196
There is a new robbery incident in the Franklin zone.

Police unit number four has been dispatched to the robbery in Franklin.

Police car number four is enroute.

There is a new medical incident in the Clinton area.

Ambulance number ten has been dispatched to the medical in Clinton.

Medical unit number ten is enroute.

There is a new medical incident in the Washington zone.

Medical unit number five has been dispatched to the medical in Washington.

Medical unit number five is enroute.

Ambulance number ten is on scene.
There is a new spill incident in the Clinton region.

There is a new spill incident in the Clinton region.

Police car number seventeen has been dispatched to the spill in Clinton.

Fire truck number ten has been dispatched to the spill in Clinton.

Fire engine number ten is enroute.

Medical transport number four is available.

There is a new fallen tree incident in the Clinton area.

There is a new fallen tree incident in the Clinton area.

There is a new fallen tree incident in the Clinton area.

There is a new fallen tree incident in the Clinton area.

Fire unit number nine has been dispatched to the fallen tree in Clinton.

Fire unit number nine has been dispatched to the fallen tree in Clinton.

Medical unit number one is available.

Medical unit number one is available.

Police car number thirteen is available.
Police unit number seventeen is on scene.

Fire truck number nine is enroute.

Medical unit number four is back at base.

Police unit number thirteen is back at base.

There is a new fight incident in the Springfield neighborhood.

Police unit number thirteen has been dispatched to the fight in Springfield.

Medical unit number seven has been dispatched to the fight in Springfield.

Medical unit number one is back at base.

Fire unit number ten is on scene.

There is a new fight incident in the Clinton zone.
Police car number nineteen has been dispatched to the fight in Clinton.

Medical transport number nine has been dispatched to the fight in Clinton.

Police car number nineteen is enroute.

Medical unit number nine is enroute.

Police car number thirteen is on scene.

Police car number four is available.

Fire unit number one is available.

Fire engine number nine is on scene.

Police unit number four is back at base.

Ambulance number seven is on scene.

There is a new fight incident in the Franklin area.
Ambulance number two has been dispatched to the fight in Franklin. |
text2wave | lame - 4_69.mp3 |
\nPolice car number four has been dispatched to the fight in Franklin. |
text2wave | lame - 4_70.mp3 |
\nPolice unit number nineteen is on scene. |
\ntext2wave | lame - 4_71.mp3 |
\nMedical transport number two is enroute. |
\ntext2wave | lame - 4_72.mp3 |
\nThere is a new fire incident in the Springfield region. |
\ntext2wave | lame - 5_1.mp3 |
\nFire engine number seven has been dispatched to the fire in Springfield. |
\ntext2wave | lame - 5_2.mp3 |
\nAmbulance number seven has been dispatched to the fire in Springfield. |
\ntext2wave | lame - 5_3.mp3 |
\nFire truck number seven is enroute. |
\ntext2wave | lame - 5_5.mp3 |
\nThere is a new robbery incident in the Clinton region. |
\ntext2wave | lame - 5_7.mp3 |
\nPolice unit number seventeen has been dispatched to the robbery in Clinton. |
\ntext2wave | lame - 5_8.mp3
Medical unit number seven is on scene.

There is a new spill incident in the Clinton neighborhood.

Fire unit number ten has been dispatched to the spill in Clinton.

Police car number twenty has been dispatched to the spill in Clinton.

Fire engine number seven is on scene.

There is a new spill incident in the Clinton neighborhood.

Police car number twenty has been dispatched to the spill in Clinton.

Fire unit number ten is enroute.

Police car number twenty is enroute.

Police unit number twenty is enroute.

There is a new accident incident in the Franklin area.

Fire unit number two has been dispatched to the accident in Franklin.

Medical unit number two has been dispatched to the accident in Franklin.

Fire unit number two has been dispatched to the accident in Franklin.

Fire unit number two has been dispatched to the accident in Franklin.

Medical unit number two has been dispatched to the accident in Franklin.
Ambulance number two is enroute.

Police car number two is enroute.

Police car number twenty is on scene.

Fire unit number two is enroute.

There is a new fire incident in the Springfield zone.

Ambulance number eight has been dispatched to the fire in Springfield.

Fire unit number eight has been dispatched to the fire in Springfield.

Medical transport number eight is enroute.

Fire truck number ten is on scene.

Medical engine number eight is enroute.

Medical unit number two is on scene.
There is a new medical incident in the Springfield region.

Ambulance number five has been dispatched to the medical in Springfield.

Medical unit number five is enroute.

Fire unit number two is on scene.

Ambulance number eight is on scene.

There is a new accident incident in the Springfield region.

Police car number fourteen has been dispatched to the accident in Springfield.

Ambulance number ten has been dispatched to the accident in Springfield.

Fire truck number three has been dispatched to the accident in Springfield.

Police unit number fourteen is enroute.

Medical unit number ten is enroute.
(3293,5,387,7,1,4,2,'three',2,'Fire truck number three is enroute.','5_44.mp3','echo "Fire truck number three is enroute." | text2wave | lame - 5_44.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,75),
(3294,5,391,5,4,2,'eight',3,'Fire engine number eight is on scene.','5_45.mp3','echo "Fire engine number eight is on scene." | text2wave | lame - 5_45.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,75),
(3295,5,396,7,4,3,'five',3,'Medical unit number five is on scene.','5_46.mp3','echo "Medical unit number five is on scene." | text2wave | lame - 5_46.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,4),
(3296,5,401,8,3,2,0,'',0,'There is a new fight incident in the Salem neighborhood.'\"5_47.mp3\"','echo \"There is a new fight incident in the Salem neighborhood.\" | text2wave | lame - 5_47.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3297,5,406,8,3,2,3,'three',1,'Medical transport number three has been dispatched to the fight in Salem.'\"5_48.mp3\"','echo \"Medical transport number three has been dispatched to the fight in Salem.\" | text2wave | lame - 5_48.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3298,5,410,8,3,2,1,'six',1,'Police car number six has been dispatched to the fight in Salem.'\"5_49.mp3\"','echo \"Police car number six has been dispatched to the fight in Salem.\" | text2wave | lame - 5_49.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3299,5,414,7,1,4,1,'fourteen',3,'Police car number fourteen is on scene.'\"5_50.mp3\"','echo \"Police car number fourteen is on scene.\" | text2wave | lame - 5_50.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3300,5,420,8,3,2,2,'three',2,'Medical transport number three is enroute.'\"5_51.mp3\"','echo \"Medical transport number three is enroute.\" | text2wave | lame - 5_51.mp3
'\"5_51.mp3\"','echo \"Medical transport number three is enroute.\" | text2wave | lame - 5_51.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3301,5,424,2,4,5,1,'seventeen',4,'Police unit number seventeen is available.'\"5_52.mp3\"','echo \"Police unit number seventeen is available.\" | text2wave | lame - 5_52.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3302,5,428,8,3,2,1,'six',2,'Police car number six is enroute.'\"5_53.mp3\"','echo \"Police car number six is enroute.\" | text2wave | lame - 5_53.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3303,5,432,2,4,5,1,'seventeen',0,'Police car number seventeen is back at base.'\"5_54.mp3\"','echo \"Police car number seventeen is back at base.\" | text2wave | lame - 5_54.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6),
(3304,5,436,7,1,4,3,'ten',3,'Ambulance number ten is on scene.'\"5_55.mp3\"','echo \"Ambulance number ten is on scene.\" | text2wave | lame - 5_55.mp3
',7,7,2,1,0,1,2,1,0,1,2,0,1,1,0,0,4,2,NULL,1,0,0,4,2,NULL,4,5,5,4,5,5,1,6)
There is a new robbery incident in the Springfield neighborhood. Police unit number sixteen has been dispatched to the robbery in Springfield.

Police unit number sixteen is enroute.

Medical transport number seven is available.

Police unit number six is on scene.

Police car number twenty is back at base.

Medical unit number seven is back at base.

Ambulance number four has been dispatched to the fire in Salem.
dispatched to the fire in Salem." | text2wave | lame - 5_67.mp3

\(\text{echo} \ "\text{Fire engine number four has been dispatched to the fire in Salem.}\" \mid \text{text2wave} \mid \text{lame - 5_68.mp3}\)

\(\text{echo} \ "\text{Police car number sixteen is on scene.}\" \mid \text{text2wave} \mid \text{lame - 5_69.mp3}\)

\(\text{echo} \ "\text{Police car number two is available.}\" \mid \text{text2wave} \mid \text{lame - 5_70.mp3}\)

\(\text{echo} \ "\text{Ambulance number four is enroute.}\" \mid \text{text2wave} \mid \text{lame - 5_71.mp3}\)

\(\text{echo} \ "\text{Police unit number two is back at base.}\" \mid \text{text2wave} \mid \text{lame - 5_72.mp3}\)

```sql
-- Definition of table `sessions`

DROP TABLE IF EXISTS `sessions`;  
CREATE TABLE `sessions` (  
`session_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
`php_session_id` varchar(100) NOT NULL,  
`session_start_time` timestamp NOT NULL DEFAULT CURRENT_TIMESTAMP ON UPDATE CURRENT_TIMESTAMP,  
`participant_IP_address` varchar(45) NOT NULL,  
`script_assignment` int(10) unsigned NOT NULL,  
`interface_assignment` int(10) unsigned NOT NULL DEFAULT '0',  
`http_user_agent` varchar(200) NOT NULL,  
`sagat_timing` int(10) unsigned NOT NULL,  
PRIMARY KEY (`session_id`) USING BTREE
) ENGINE=InnoDB AUTO_INCREMENT=264 DEFAULT CHARSET=latin1;

-- Definition of table `status_types`

DROP TABLE IF EXISTS `status_types`;  
CREATE TABLE `status_types` (  
`status_type_id` int(10) unsigned NOT NULL AUTO_INCREMENT,  
`status_type_description` varchar(45) NOT NULL,  
PRIMARY KEY (`status_type_id`)  
) ENGINE=InnoDB AUTO_INCREMENT=5 DEFAULT CHARSET=latin1;

-- Dumping data for table `status_types`

```
INSERT INTO `status_types` VALUES  (0,'at base'),
(1,'dispatched to an incident'),
(2,'enroute to an incident'),
(3,'working on an incident'),
(4,'available ');

PHP code web-based modules

PHP source code for file: include_for_database_access.php

```php
<?PHP

function connect_to_mysql() {
    $db_host    ="";
    $db_user    ="";
    $db_pass    ="";
    $db_name    ="experiment";

    $conn = mysql_connect($db_host, $db_user, $db_pass) or die ("Could not connect to mysql because ".mysql_error());
    mysql_select_db($db_name) or die ("Could not select database because ".mysql_error());
    return $conn;
} //function connect_to_mysql()

function scrub_input($input_string) {
    $output_string = stripslashes($input_string);
    $output_string = trim($output_string);
    // escape quotes
    $output_string = str_replace("\", "\\\", $output_string);
    $output_string = str_replace(\"", "\\\", $output_string);
    // look for suspicious substrings
    if (   (stristr($output_string, "--") >= 0)
        or (stristr($output_string, ";") >= 0) ) {
        $output_string="";
    } // if
    return ($output_string);
} // function scrub_input

?>

PHP source code for file: index.php

<html>
<head>
<script type="text/javascript">

</script>
</head>
</html>
```
<!--
var step = 8;
var current_color = 127;

function updateTimer() {
    if (current_color <= 16) step = 8;
    if (current_color >= 193) step = -8;
    current_color += step;
    document.getElementById("button_wrapper").style.backgroundColor = "rgb(\"+current_color+\",\"+current_color+\",255\")
    setTimeout("updateTimer()", 100);
} // function updateTimer()

function startup() {
    // maximize the browser window
    window.moveTo(0,0);
    window.resizeTo(screen.width, screen.height);
    updateTimer();
} //function startup()

//-->
</script>

<title>The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness</title>
</head>

<body bgcolor="#FFFFFF" text="#000000" vlink="#000088" onLoad="startup();">

<table width="90%" border="0" cellspacing="0" cellpadding="10" align="center">
<tr><td>

<div align="center"><font size="+2">The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness</font></div><br>

Welcome and thank you for visiting my "user interface experiment" web page. This study is being conducted for research purposes, and research participants are being sought. Anyone able to use a typical personal computer and web browser may participate.<br>

I am working toward a Ph.D. in Information Sciences and Technology at the Pennsylvania State University. This web application is the data-gathering component of an experiment I am conducting as a part of that effort. I very much appreciate your time, and I have arranged for a set of drawings to be held, awarding gift certificates, to randomly-selected participants who complete the experiment. Here is what is involved:<br>

The next page will apprise you of your rights as a participant in this study, and allow you to gracefully decline to participate. If you continue (please do), the following page will provide some more details and gather preliminary information from you. You will then be taken to a web page which you will use to record activity into a database. The activities I will ask you to record will come as audio messages which will start out slow and then get faster and faster. The messages will describe the simulated activity of emergency resources (police, fire, and medical) in a fictional city. I am interested in the speed and accuracy of your understanding the audio messages. The entire process should take about twenty minutes.<br>

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Once you have completed the experiment, you will be shown a score and ranking, so you can get an idea of how well you did compared to others who have participated. At this point, you will have the option to submit an e-mail address which will be entered into a couple of random drawings for prizes to be held at the conclusion of the study. If you submit an e-mail address, it will be included in a drawing from all submissions. In addition, if your score is in the top 25% of all of the scores, the submitted e-mail address will be included in a separate drawing for another prize. Prizes will be gift certificates for a variety of businesses, ranging in values from $10 to $50. (Please note: The e-mail address you supply and the score you achieve will not be correlated with any other data you provide through the course of the experiment.)

If you have any questions or concerns regarding this research, please contact:
Art Jones
118B Keller Building
University Park, PA 16802
email: ajones@ist.psu.edu

---

function updateTimer() {
    var step = 8;
    var current_color = 127;
    if (current_color <= 16) step = 8;
    if (current_color >= 193) step = -8;
    current_color += step;
    document.getElementById("button_wrapper").style.backgroundColor = "rgb(\+current_color+,\+current_color+,255)";
    setTimeout("updateTimer()", 100);
} // function updateTimer()

function startup() {

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window.moveTo(0, 0);
window.resizeTo(screen.width, screen.height)

alert("Attached to this page is an audio file which should start playing automatically. This experiment requires your browser to be able to play sound files. If you do not hear any sound after you press OK, please check your volume settings, and look for error messages. In Internet Explorer, there may be a message at the top of the page, just under the address asking for permission to install an Active-X control. With FireFox, a message may appear asking if you want to install the Quicktime Plug-In. If you can not hear any sound, and are not comfortable enabling these sound features, I thank you very much.");

updateTimer();

} //function startup()

//-->
</script>

<title>The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness - Informed Consent Form</title>

<br><h1>Informed Consent</h1>
<table width="100%" border="0" cellspacing="0" cellpadding="0"><tr valign="middle">
<td width="70%">
<h2>Title of Project: </h2>
The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness<br>
<br>This research project is in partial fulfillment of the requirements for a Ph.D. degree through The Pennsylvania State University's College of Information Sciences and Technology<br>

This study is being conducted for research purposes.<br>
</td><td align="center">
<table width="90%" border="1" cellspacing="0" cellpadding="2"><tr><td>
ORP OFFICE USE ONLY – DO NOT REMOVE OR MODIFY:<br>
This informed consent form (Doc.#1 ) was reviewed and approved by the Social Science Institutional Review Board (IRB#30319) at The Pennsylvania State University on 02-02-15-09. It will expire on 02-14-10.<br>

(LSY)<br>
</td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr><tr><td align="center"></td></tr></table>
</td></tr></table>
<hr>
<table><tr>
<td width="50%">
<h2>Primary Investigator: </h2>
Arthur C. Jones, MS, EMT-P, Ph.D. Candidate<br>
College of Information Sciences and Technology<br>
</td></tr></table>
The study will quantitatively assess the ability of subjects to interpret audio messages and record those interpretations into a database via a variety of interface designs, while simultaneously formulating situational awareness of the dynamic environment reported by the messages.

Potential Benefits:
These functions being studies are derived from the activities of emergency operations center personnel, who may benefit by improved information management techniques resulting from this study.

Procedures:
You will be lead through the collection of some basic demographic information, any piece of which you may refuse to answer without penalty. You will then be taken to a web page which you will use to record activity into a database. The activities you will be asked to record will come as audio messages which will start out slow and then get faster and faster. The messages will describe the simulated activity of emergency resources (police, fire, and medical) in a fictional city. The speed and accuracy of your submissions will be recorded for analysis. At random times, the simulation will freeze and you will be asked to supply some information designed to test your understanding of the simulated situation. There are no risks or discomforts foreseen in the procedures of this study.

Compensation:
At the conclusion of your session, you will have the option to submit an e-mail address which will be entered into a set of random drawings for gift certificates to be held at the conclusion of the study. There will be two drawings, each with three winners of equal value. The first drawing will be inclusive of all participants who complete the study, and elect to submit an e-mail address for inclusion in the drawings. The second, "bonus drawing", will be inclusive of all participants who score at or above the 75th percentile of all participants, and who elect to submit an e-mail address for inclusion in the drawings. Please be aware that total payments within one calendar year that exceed $600 will require the University to report these payments to the IRS. This may require you to claim the compensation that you receive for participation in this study as taxable income.

Time Requirements:
Complete participation in a session will take approximately 20-30 minutes.
conclusion of this study will be held distinctly from the other collected data, and will used only for the specified purpose. Addresses will not be shared with any person or organization besides the P.I., and will be deleted following the prize drawings.

<h2>Participation:</h2>
Participation is voluntary. Participants may refuse to answer any question and may withdraw their participation at any time. (This may be done my simply ceasing to respond to the experiment's stimuli and/or closing the browser session.)
You must be at least 18 years of age to participate in this study.

<h2>Questions:</h2>
Participants have the right to ask questions and have those questions answered. Any questions regarding this research may be directed to the primary investigator named above. If you have questions about your rights as a research participant, contact Penn State's Office for Research Protections at 814-865-1775. If you feel you have been harmed in any way by your participation in this study, please contact either the P.I. named above or Penn State's Office for Research Protections.

<h2>Acknowledgement:</h2>
By clicking on the "I Agree" button below, you acknowledge that you have read and understand all of the points listed on this page. You are encouraged to print this page for your own records.

<form action="demographics.php">
<table id="button_wrapper" border="0" cellspacing="0" cellpadding="10" align="center" bgcolor="#000088">
<tr><td><input type="submit" value="  I AGREE  ">
</td></tr></table>
</form>

<?PHP
    // check for illegal referrers
    $referring_url  = strtoupper($_SERVER['HTTP_REFERER']);
    $current_url    = "http://" . $_SERVER['HTTP_HOST'] . $_SERVER['PHP_SELF'];
    $allowed_url    = strtoupper(substr($current_url,0,(1+strripos($current_url,"/"))) . "informed_consent.php");
    if  ($referring_url != $allowed_url) header("location:error.php?desc=illegal referrer to demographics.php");
    session_start();
    include 'include_for_database_access.php';
    $db_connection = connect_to_mysql();
    // select a random script for this session
    if ($db_connection != 0) {
        $sql  = "SELECT MAX(script_id) AS max_script FROM scripts;";
    }
$results = mysql_query($sql, $db_connection) or die("Could not read data because: ". mysql_error() . "   SQL: ". $sql);
if ($tuple = mysql_fetch_array($results)) {
$max_script = $tuple['max_script'];
} else {
    echo "problem with data retrieval" . "<BR>
";
} // if-else successful data retrieval
} else {
    echo "problem with DB connection<BR>
";
}// if-else DB connection
$sql_selection = rand(1,$max_script);

if ($db_connection != 0) {
    $sql = "SELECT COUNT(*) AS script_length FROM scripts WHERE script_id=" . $script_selection . ";";
    $results = mysql_query($sql, $db_connection) or die("Could not read data because: ". mysql_error() . "   SQL: ". $sql);
    if ($tuple = mysql_fetch_array($results)) {
        $script_length = $tuple['script_length'];
    } else {
        echo "problem with data retrieval" . "<BR>
";
    } // if-else successful data retrieval
} else {
    echo "problem with DB connection<BR>
";
}// if-else DB connection
$sql = "SELECT COUNT(*) AS icount FROM (sessions
JOIN sagat_responses ON sessions.session_id = sagat_responses.session_id)
GROUP BY interface_assignment ORDER BY icount ASC LIMIT 1;";
$results = mysql_query($sql, $db_connection) or die("Could not read data because: ". mysql_error() . "   SQL: ". $sql);
if ($tuple = mysql_fetch_array($results)) {
    $interface_selection = $tuple['interface_assignment'];
} // if
} else {
    echo "problem with DB connection<BR>
";
}// if-else DB connection

// declare a new user session
$sql = "INSERT INTO sessions (php_session_id, participant_IP_address, script_assignment, interface_assignment, http_user_agent, sagat_timing) VALUES 
('$_COOKIE['PHPSESSID']')."'" . 
'$_SERVER['REMOTE_ADDR']].'"' . 
'$script_selection.'."' . 
'$interface_selection.'."' . 
'$_SERVER['HTTP_USER_AGENT']]].'"'. 214
if ($db_connection != 0) {
    $results = mysql_query($sql, $db_connection) or die ("Could not write 
data because: " . mysql_error() . " SQL: " . $sql);
    // this SQL will retrieve the new record (allowing access to the auto-
    assigned session_id)
    $sql = "SELECT session_id FROM sessions WHERE php_session_id='" .
            $_COOKIE['PHPSESSID'] . "' ORDER BY session_start_time DESC LIMIT 1;";
    $results = mysql_query($sql, $db_connection) or die ("Could not read data 
because: " . mysql_error() . " SQL: " . $sql);
    if ($tuple = mysql_fetch_array($results)) {
        $user_session = $tuple['session_id'];
    } else {
        echo "problem with data retrieval" . "<BR>";
    } // if-else successful data retrieval
} else {
    echo "problem with DB connection<BR>";
} // if-else DB connection

<html>
<head>
<script type="text/javascript">

function eval_response(radioObj) {
    // this function will return the numeric value of the selected radio
    button within a given set
    var return_val = 0; // default return is 0
    for (i=0; i<radioObj.length; i++) {
        if(radioObj[i].checked) return_val = eval(radioObj[i].value);
    } // for
    return(return_val);
} // eval_response

function checkSubmit(formObj) {
    // this function is for verifying input and performing pre-submit
    caluculations just before form data is sent to the target processing script

    // calculate the modified Alert Cognitive Style score
    var alert_score = 0;
    alert_score += eval_response(formObj.q01);
    alert_score += eval_response(formObj.q02);
    alert_score += eval_response(formObj.q03);
    alert_score += eval_response(formObj.q04);
    alert_score += eval_response(formObj.q05);
    alert_score += eval_response(formObj.q06);
    alert_score += eval_response(formObj.q07);
    alert_score += eval_response(formObj.q08);
    alert_score += eval_response(formObj.q09);
    alert_score += eval_response(formObj.q10);
    alert_score += eval_response(formObj.q11);
    alert_score += eval_response(formObj.q12);
    alert_score += eval_response(formObj.q13);
    alert_score += eval_response(formObj.q14);
    alert_score += eval_response(formObj.q15);
    alert_score += eval_response(formObj.q16);
    alert_score += eval_response(formObj.q17);
    alert_score += eval_response(formObj.q18);
    alert_score += eval_response(formObj.q19);
```javascript
alert_score += eval_response(formObj.q20);
alert_score += eval_response(formObj.q21);
// store the resulting score
formObj.alert_score.value = alert_score;
return(true);
}

function Filter_IntegersOnly(FieldValue) {
    // This function should be called from an onKeyUp event with a reference to the
    // current input field (ex.: onKeyUp="javascript:Filter_IntegersOnly(this)"
    // Any dis-allowed character entry will be voided, and a message displayed.
    var AllowedCharacters = "0123456789";
    if(AllowedCharacters.indexOf(FieldValue.value.charAt((FieldValue.value.length) - 1)) < 0) {
        FieldValue.value = FieldValue.value.substring(0, (FieldValue.value.length) - 1);
        alert("Input Field: \"" + FieldValue.name + \"\"\nOnly numeric characters are allowed here!");
        FieldValue.focus();
    } /* end if */
} /* function */

function Verify_IntegersOnly(FieldValue) {
    // This function should be called from an onBlur event with a reference to the
    // current input field (ex.: onBlur="javascript:Verify_IntegersOnly(this)"
    // Any dis-allowed characters will be voided. This function should be used in
    // addition to the Filter_IntegersOnly() function to eliminate characters which
    // could slip through by dual key presses.
    var AllowedCharacters = "0123456789";
    for (var i=(FieldValue.value.length-1); i>=0; i--) {
        if (AllowedCharacters.indexOf(FieldValue.value.charAt(i)) < 0) {
            FieldValue.value = FieldValue.value.substring(0, (i)) +
            FieldValue.value.substring((i+1), FieldValue.value.length);
        } /* end if */
    } /* end for */
} /* end function */

</script>

<title>The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness - demographic data collection form</title>
</head>

<BODY bgcolor="#8888FF" text="#000000" link="#DDDDFF" vlink="#DDDDFF" align="#FF0000">

<!-- DEBUGING MESSAGES
<CENTER><TABLE WIDTH="90%" BORDER="0" CELLCOLOR="#000000" CELLPADDING="5" ALIGN="CENTER"><TR BGCOLOR="#FF0000"><TD ALIGN="left" VALIGN="top">
</?PHP
```
Thank you for agreeing to participate in my experiment. I would like to start by collecting some basic information about you. Completeness would be appreciated. None of your responses can be tied back to you as an individual. Still, it is your option to refuse to answer any question(s).

**Gender?**

- Male<br>
- Female<br>

**How old are you?**

- 18-24<br>
- 25-34<br>
- 35-44<br>
- 45+

**Do you have any uncorrected problems with your hearing?**

- No<br>
- Yes

**Do you have any uncorrected problems with your vision?**

- No<br>
- Yes
<table>
<thead>
<tr>
<th>Question</th>
<th>Radio Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are you having any problems with the controlled movement of your hands and arms which may affect your ability to use a computer mouse?</td>
<td>No</td>
</tr>
<tr>
<td>Do you have any prior work experience in 9-1-1 or other command-and-control facilities?</td>
<td>No</td>
</tr>
<tr>
<td>How many hours (rounded to a whole number) do you spend working on a computer each day, on average?</td>
<td></td>
</tr>
<tr>
<td>How many hours (rounded to a whole number) do you spend playing computer games each day, on average?</td>
<td></td>
</tr>
</tbody>
</table>

These questions are from the Alert Scale of Cognitive Style, by Dr. Loren D. Crane, Western Michigan University, 1989. The scoring scheme has been modified to accommodate the PSU-ORP requirements that answers should not be required. In place of the traditional 0/1 scoring, I have used a -1/1 system - This will adjust the scale so that positive values indicate right-brain and negative values indicate left-brain dominance. These are some questions about the way you think.
For this section, you should select the statement from each pair which is most true about yourself. It is important that each pair has one option selected.

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>It's fun to take risks.</td>
<td>I have fun without taking risks.</td>
</tr>
<tr>
<td></td>
<td>I look for new ways to do old jobs.</td>
<td>When one way works well, I don't change it.</td>
</tr>
<tr>
<td></td>
<td>I begin many jobs that I never finish.</td>
<td>I finish a job before starting a new one.</td>
</tr>
<tr>
<td></td>
<td>I'm not very imaginative in my work.</td>
<td>I use my imagination in everything I do.</td>
</tr>
<tr>
<td></td>
<td>I can analyze what is going to happen next.</td>
<td>I can sense what is going to happen next.</td>
</tr>
<tr>
<td></td>
<td>I try to find the one best way to solve a problem.</td>
<td>I try to find different answers to problems.</td>
</tr>
<tr>
<td></td>
<td>My thinking is like pictures going through my head.</td>
<td>My thinking is like words going through my head.</td>
</tr>
<tr>
<td></td>
<td>I agree with new ideas before other people do.</td>
<td>I question new ideas more than other people do.</td>
</tr>
</tbody>
</table>

219
<table>
<thead>
<tr>
<th>Question</th>
<th>Option 1</th>
<th>Option 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>q09</td>
<td>Other people don't understand how I organize things.</td>
<td>Other people think I organize well.</td>
</tr>
<tr>
<td>q10</td>
<td>I have good self-discipline.</td>
<td>I usually act on my feelings.</td>
</tr>
<tr>
<td>q11</td>
<td>I plan time for doing my work.</td>
<td>I don't think about the time when I work.</td>
</tr>
<tr>
<td>q12</td>
<td>With a hard decision, I choose what I know is right.</td>
<td>With a hard decision, I choose what I feel is right.</td>
</tr>
<tr>
<td>q13</td>
<td>I do easy things first and important things later.</td>
<td>I do the important things first and the easy things later.</td>
</tr>
<tr>
<td>q14</td>
<td>Sometimes in a new situation, I have too many ideas.</td>
<td>Sometimes in a new situation, I don't have any ideas.</td>
</tr>
<tr>
<td>q15</td>
<td>I have to have a lot of change and variety in my life.</td>
<td>I have to have an orderly and well-planned life.</td>
</tr>
<tr>
<td>q16</td>
<td>I know I'm right, because I have good reasons.</td>
<td>I know I'm right, even without good reasons.</td>
</tr>
<tr>
<td>q17</td>
<td>I spread my work evenly over the time I have.</td>
<td>I prefer to do my work at the last minute.</td>
</tr>
<tr>
<td>q18</td>
<td>I keep everything in a particular place.</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Option 1</td>
<td>Option 2</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>-----------------------------------------------------------</td>
<td>-----------------------------------------------------------</td>
</tr>
<tr>
<td>Where I keep things depends on what I'm doing.</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q18&quot; value=&quot;1&quot;&gt;</td>
<td></td>
</tr>
<tr>
<td>I have to make my own plans.</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q19&quot; value=&quot;1&quot;&gt;I have to</td>
<td>I can follow anyone's plans.</td>
</tr>
<tr>
<td>I am a very flexible and unpredictable person.</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q20&quot; value=&quot;1&quot;&gt;I am a very</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q20&quot; value=&quot;-1&quot;&gt;I am a</td>
</tr>
<tr>
<td></td>
<td>flexible and unpredictable person.</td>
<td>consistent and stable person.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With a new task, I want to find my own way of doing it.</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q21&quot; value=&quot;1&quot;&gt;With a new</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;q21&quot; value=&quot;-1&quot;&gt;With a new</td>
</tr>
<tr>
<td></td>
<td>task, I want to find my own way of doing it.</td>
<td>task, I want to be told the best way to do it.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This section is for current students. Remember that your answers can not be tied back to you as an individual.
<select name="major" size="1">
  <option value="0">not a student / don't want to answer</option>
  <option value="1">Information Sciences and Technology</option>
  <option value="2">Engineering</option>
  <option value="3">Psychology</option>
  <option value="4">Communications</option>
  <option value="5">Business</option>
  <option value="9">- Other -</option>
</select>

What is your GPA?

<select name="gpa" size="1">
  <option value="0">not a student / don't want to answer</option>
  <option value="40">4.00</option>
  <option value="35">3.50 - 3.99</option>
  <option value="30">3.00 - 3.49</option>
  <option value="25">2.50 - 2.99</option>
  <option value="20">2.00 - 2.49</option>
  <option value="10">less than 2.00</option>
</select>

Thanks for answering the questions. Once you click the button to the right, you will be taken to the page where you will participate in the main part of this experiment.

<input type="submit" value="Submit my info and let the game begin.">

<input type="hidden" name="alert_score" value="">
<input type="hidden" name="user_session" value="&lt;?php echo $user_session; ?&gt;">
<input type="hidden" name="script_selection" value="&lt;?php echo $script_selection; ?&gt;">
<input type="hidden" name="interface_selection" value="&lt;?php echo $interface_selection; ?&gt;">
<input type="hidden" name="sagat_timing" value="&lt;?php echo $sagat_timing; ?&gt;">
<?php

// check for illegal referrers
$referring_url = strtoupper($_SERVER['HTTP_REFERER']);
$current_url = "http://" . $_SERVER['HTTP_HOST'] . $_SERVER['PHP_SELF'];
$allowed_url = strtoupper(substr($current_url,0,(1+strripos($current_url,"/"))))."demographics.php";
//if ($referring_url != $allowed_url)
header("location:error.php?desc=illegal referrer to ". $_SERVER['PHP_SELF']);

include 'include_for_database_access.php';
$db_connection = connect_to_mysql();

$user_session = stripslashes($_REQUEST['user_session']);
$script_selection = stripslashes($_REQUEST['script_selection']);
$interface_selection = stripslashes($_REQUEST['interface_selection']);
$sagat_timing = stripslashes($_REQUEST['sagat_timing']);

// we need to record the collected demographic data
$sql = "INSERT INTO demographics (" .
  "session_id," .
  "age_cat," .
  "gender," .
  "hearing_problems," .
  "vision_problems," .
  "movement_problems," .
  "prior_experience," .
  "computer_time," .
  "video_games," .
  "student_semester," .
  "student_gpa," .
  "student_major," .
  "CogStyle_Q1," .
  "CogStyle_Q2," .
  "CogStyle_Q3," .
  "CogStyle_Q4," .
  "CogStyle_Q5," .
  "CogStyle_Q6," .
  "CogStyle_Q7," .
  "CogStyle_Q8," .
  "CogStyle_Q9," .
  "CogStyle_Q10," .
  "CogStyle_Q11," .
  "CogStyle_Q12," .
  "CogStyle_Q13," .
  "CogStyle_Q14," .
  "CogStyle_Q15," .
  "CogStyle_Q16," .
  "CogStyle_Q17," .
  "CogStyle_Q18","");
"CogStyle_Q19", "
"CogStyle_Q20", "
"CogStyle_Q21", "
"CogStyle_Score".
" ) VALUES ("
$user_session", 
(!isset($_REQUEST['age_cat']) ? "NULL" :stripslashes($_REQUEST['age_cat'])).", 
(!isset($_REQUEST['gender']) ? "NULL" :stripslashes($_REQUEST['gender'])).", 
(!isset($_REQUEST['hearing_problems']) ? "NULL" :stripslashes($_REQUEST['hearing_problems'])).", 
(!isset($_REQUEST['vision_problems']) ? "NULL" :stripslashes($_REQUEST['vision_problems'])).", 
(!isset($_REQUEST['movement_problems']) ? "NULL" :stripslashes($_REQUEST['movement_problems'])).", 
(!isset($_REQUEST['prior_experience']) ? "NULL" :stripslashes($_REQUEST['prior_experience'])).", 
(!isset($_REQUEST['computer_work_hours']) ? "NULL" :stripslashes($_REQUEST['computer_work_hours'])).", 
(!isset($_REQUEST['computer_game_hours']) ? "NULL" :stripslashes($_REQUEST['computer_game_hours'])).", 
(!isset($_REQUEST['semester']) ? "NULL" :stripslashes($_REQUEST['semester'])).", 
(!isset($_REQUEST['gpa']) ? "NULL" :stripslashes($_REQUEST['gpa'])).", 
(!isset($_REQUEST['major']) ? "NULL" :stripslashes($_REQUEST['major'])).", 
(!isset($_REQUEST['q01']) ? "NULL" :stripslashes($_REQUEST['q01'])).", 
(!isset($_REQUEST['q02']) ? "NULL" :stripslashes($_REQUEST['q02'])).", 
(!isset($_REQUEST['q03']) ? "NULL" :stripslashes($_REQUEST['q03'])).", 
(!isset($_REQUEST['q04']) ? "NULL" :stripslashes($_REQUEST['q04'])).", 
(!isset($_REQUEST['q05']) ? "NULL" :stripslashes($_REQUEST['q05'])).", 
(!isset($_REQUEST['q06']) ? "NULL" :stripslashes($_REQUEST['q06'])).", 
(!isset($_REQUEST['q07']) ? "NULL" :stripslashes($_REQUEST['q07'])).", 
(!isset($_REQUEST['q08']) ? "NULL" :stripslashes($_REQUEST['q08'])).", 
(!isset($_REQUEST['q09']) ? "NULL" :stripslashes($_REQUEST['q09'])).", 
(!isset($_REQUEST['q10']) ? "NULL" :stripslashes($_REQUEST['q10'])).", 
(!isset($_REQUEST['q11']) ? "NULL" :stripslashes($_REQUEST['q11'])).", 
(!isset($_REQUEST['q12']) ? "NULL" :stripslashes($_REQUEST['q12'])).", 
(!isset($_REQUEST['q13']) ? "NULL" :stripslashes($_REQUEST['q13'])).", 
(!isset($_REQUEST['q14']) ? "NULL" :stripslashes($_REQUEST['q14'])).", 
(!isset($_REQUEST['q15']) ? "NULL" :stripslashes($_REQUEST['q15'])).", 
(!isset($_REQUEST['q16']) ? "NULL" :stripslashes($_REQUEST['q16'])).");
"}
if ($db_connection != 0) {
    $results = mysql_query($sql, $db_connection) or die ('Could not write data because: ' . mysql_error() . ' SQL: ' . $sql);
} else {
    echo "problem with DB connection<br>
";
} // if-else DB connection

<?
<html>
<head>
<script type="text/javascript">
// variables used for managing events
var log_text = "";
var start_time = new Date();
var timer = 0;
var time_since_last_message = 0;
var total_time_from_message_to_report = 0;
var time_since_last_report = 0;
var current_report = 0;
var current_message = 0;
var Main_Display = "";
var SAGAT_Form = "";
var EXIT_Form = "";

// variable arrays for notification message timing / text
var message_time = new Array();
var message_text = new Array();

// variable arrays for the "scoreboard"
var current_incident_count = new Array();
var total_incident_count = new Array();
var current_type_1_incidents = new Array();
var current_type_2_incidents = new Array();
var current_type_3_incidents = new Array();
var current_type_4_incidents = new Array();
var current_type_5_incidents = new Array();
var current_type_6_incidents = new Array();
var current_type_7_incidents = new Array();
var total_type_1_incidents = new Array();

225
226

var total_type_2_incidents = new Array();
var total_type_3_incidents = new Array();
var total_type_4_incidents = new Array();
var total_type_5_incidents = new Array();
var total_type_6_incidents = new Array();
var total_type_7_incidents = new Array();
var current_location_1_incidents = new Array();
var current_location_2_incidents = new Array();
var current_location_3_incidents = new Array();
var current_location_4_incidents = new Array();
var current_location_5_incidents = new Array();
var current_police_assignments = new Array();
var current_fire_assignments = new Array();
var current_medical_assignments = new Array();
var total_location_1_incidents = new Array();
var total_location_2_incidents = new Array();
var total_location_3_incidents = new Array();
var total_location_4_incidents = new Array();
var total_location_5_incidents = new Array();
var total_police_assignments = new Array();
var total_fire_assignments = new Array();
var total_medical_assignments = new Array();

// message array definitions built by PHP from DB script data...

<?PHP
$results = mysql_query("SELECT * FROM scripts WHERE script_id=", $script_selection . " ORDER BY script_time ASC LIMIT 100;", $db_connection)
or die("Could not read data because ".mysql_error());
$message_num = 0;

while ($tuple = mysql_fetch_array($results)) {
    $message_num++;
    echo "message_time[" . $message_num . "]='" . $tuple['script_time'] . "';
    // message text is only needed for interface variant #3
    if ($interface_selection == 3) echo "message_text[" . $message_num . "]='" . $tuple['message_text'] . "';
    echo "current_incident_count[" . $message_num . "]='" . $tuple['concurrent_incidents'] . "';
    echo "total_incident_count[" . $message_num . "]='" . $tuple['total_incidents'] . "';
    echo "current_type_1_incidents[" . $message_num . "]='" . $tuple['concurrent_type_1_incidents'] . "';
    echo "current_type_2_incidents[" . $message_num . "]='" . $tuple['concurrent_type_2_incidents'] . "';
    echo "current_type_3_incidents[" . $message_num . "]='" . $tuple['concurrent_type_3_incidents'] . "';
    echo "current_type_4_incidents[" . $message_num . "]='" . $tuple['concurrent_type_4_incidents'] . "';
    echo "current_type_5_incidents[" . $message_num . "]='" . $tuple['concurrent_type_5_incidents'] . "';
    echo "current_type_6_incidents[" . $message_num . "]='" . $tuple['concurrent_type_6_incidents'] . "';

    echo "current_location_1_incidents[" . $message_num . "]='" . $tuple['concurrent_location_1_incidents'] . "';
    echo "current_location_2_incidents[" . $message_num . "]='" . $tuple['concurrent_location_2_incidents'] . "';
    echo "current_location_3_incidents[" . $message_num . "]='" . $tuple['concurrent_location_3_incidents'] . "';
    echo "current_location_4_incidents[" . $message_num . "]='" . $tuple['concurrent_location_4_incidents'] . "';
    echo "current_location_5_incidents[" . $message_num . "]='" . $tuple['concurrent_location_5_incidents'] . "';

    echo "total_location_1_incidents[" . $message_num . "]='" . $tuple['total_location_1_incidents'] . "';
    echo "total_location_2_incidents[" . $message_num . "]='" . $tuple['total_location_2_incidents'] . "';
    echo "total_location_3_incidents[" . $message_num . "]='" . $tuple['total_location_3_incidents'] . "';
    echo "total_location_4_incidents[" . $message_num . "]='" . $tuple['total_location_4_incidents'] . "';
    echo "total_location_5_incidents[" . $message_num . "]='" . $tuple['total_location_5_incidents'] . "';

    echo "total_type_1_incidents[" . $message_num . "]='" . $tuple['total_type_1_incidents'] . "';
    echo "total_type_2_incidents[" . $message_num . "]='" . $tuple['total_type_2_incidents'] . "';
    echo "total_type_3_incidents[" . $message_num . "]='" . $tuple['total_type_3_incidents'] . "';
    echo "total_type_4_incidents[" . $message_num . "]='" . $tuple['total_type_4_incidents'] . "';
    echo "total_type_5_incidents[" . $message_num . "]='" . $tuple['total_type_5_incidents'] . "';
    echo "total_type_6_incidents[" . $message_num . "]='" . $tuple['total_type_6_incidents'] . "';
    echo "total_type_7_incidents[" . $message_num . "]='" . $tuple['total_type_7_incidents'] . "';

    echo "current_police_assignments[" . $message_num . "]='" . $tuple['current_police_assignments'] . "';
    echo "current_fire_assignments[" . $message_num . "]='" . $tuple['current_fire_assignments'] . "';
    echo "current_medical_assignments[" . $message_num . "]='" . $tuple['current_medical_assignments'] . "';
    echo "total_police_assignments[" . $message_num . "]='" . $tuple['total_police_assignments'] . "';
    echo "total_fire_assignments[" . $message_num . "]='" . $tuple['total_fire_assignments'] . "';
    echo "total_medical_assignments[" . $message_num . "]='" . $tuple['total_medical_assignments'] . "';

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echo "current_type_7_incidents[" . $message_num . "]=" . $tuple["concurrent_type_7_incidents"] . ";
";
$tuple["type_1_incident_total"] . ";
";
$tuple["type_2_incident_total"] . ";
";
$tuple["type_3_incident_total"] . ";
";
$tuple["type_4_incident_total"] . ";
";
$tuple["type_5_incident_total"] . ";
";
$tuple["type_6_incident_total"] . ";
";
$tuple["type_7_incident_total"] . ";
";
$tuple["concurrent_incidents_in_location_1"] . ";
";
$tuple["concurrent_incidents_in_location_2"] . ";
";
$tuple["concurrent_incidents_in_location_3"] . ";
";
$tuple["concurrent_incidents_in_location_4"] . ";
";
$tuple["concurrent_incidents_in_location_5"] . ";
";
$tuple["location_1_incident_total"] . ";
";
$tuple["location_2_incident_total"] . ";
";
$tuple["location_3_incident_total"] . ";
";
$tuple["location_4_incident_total"] . ";
";
$tuple["location_5_incident_total"] . ";
";
$tuple["concurrent_police_assignments"] . ";
";
$tuple["concurrent_fire_assignments"] . ";
";
$tuple["concurrent_medical_assignments"] . ";
";
$tuple["police_assignments_total"] . ";
";
$tuple["fire_assignments_total"] . ";
";
$tuple["medical_assignments_total"] . ";
";
} // while still more data

?>

var event_for_sagat = <?PHP echo ($sagat_timing); ?>; // The timing of the SAGAT assessment will be calculated from this event number
function logItem(message){
    // build a timestamp string
    var clock = new Date(); // get the current time
    // format the date elements
    var stampYear = String(clock.getFullYear());
    var stampMonth = String(clock.getMonth() + 1); // JS months start at 0
    if (clock.getMonth() < 9) stampMonth = "0" + stampMonth;
    var stampDate = String(clock.getDate());
    if (clock.getDate() < 10) stampDate = "0" + stampDate;
    // format the time elements
    var stampHours = String(clock.getHours());
    if (clock.getHours() < 10) stampHours = "0" + stampHours;
    var stampMinutes = String(clock.getMinutes());
    if (clock.getMinutes() < 10) stampMinutes = "0" + stampMinutes;
    var stampSeconds = String(clock.getSeconds());
    if (clock.getSeconds() < 10) stampSeconds = "0" + stampSeconds;
    // concatenate the elements
    var stampString = stampYear + stampMonth + stampDate + stampHours +
    stampMinutes + stampSeconds;
    // log the message with a leading timestamp
    log_text += (stampString + ":	" + message + 
    "\n");
} // function logItem(message)

function eval_response(radioObj) {
    // this function will return the numeric value of the selected radio button
    // within a given set
    var return_val = 0; // default return is 0
    for (i=0; i<radioObj.length; i++) {
        if(radioObj[i].checked) return_val = eval(radioObj[i].value);
    } // for
    return(return_val);
} // function eval_response(radioObj)

function startup() {
    logItem("ACTIVITY LOG BEGIN for user <?PHP echo $user_session; ?>");
    // maximize the browser window
    // window.moveTo(0, 0);
    // window.resizeTo(screen.width, screen.height)
    current_message++; // set up for the first message
    // notify the monitoring routine
}
reportAction('action=begin&user=\<?PHP\ echo $user_session; ?>&time='+timer);

// and start the clock
updateTimer();
}

function startup()

function playSound(soundobj) {
    var thissound= eval("document." + soundobj); // get a reference object for the given sound
    logItem("playing " + soundobj + " at time " + timer);
    thissound.Play();
}

function stopSound(soundobj) {
    var thissound= eval("document." + soundobj); // get a reference object for the given sound
    thissound.Stop();
}

function updateScoreboard(message_num) {
    if (message_num < 1) return;
    function formatDisplay(input_value) {
        // this function is defined from within PHP and will vary depending upon the interface assignment
        if (input_value > 0) {
            <?PHP if ($interface_selection == 1) { ?>
            return("&nbsp;&lt;font size='-1' color='#0000)c" + input_value + 
"&lt;/font>";
            <?PHP } else { ?>
            return("&lt;table width='" + (20 * input_value) + '" border='0'
            cellspacing='0' cellpadding='1' align='left' bgcolor='#0000FF'&gt;&lt;tr&gt;&lt;td
            align='right'&gt;&lt;font size='-1' color='#FFFFFF'" + input_value + 
"&lt;/font&gt;&lt;/td&gt;&lt;/tr&gt;&lt;/table&gt;";
            // for (var x=1; x<=input_value; x++) return_string += "&lt;img
            src='icons/police.gif' alt='' width='24' height='24' border='0'>";
            // return(return_string);
            <?PHP } // if-else ($interface_selection == 1)?
        } else {
            return("&lt;font size='-1' color='#FFFFFF'&gt;&lt;/font&gt;");
        } // if-else
    } // function formatDisplay()

    document.getElementById("current_type_1_incidents").innerHTML = 
    formatDisplay(current_type_1_incidents[message_num]);
document.getElementById("current_type_2_incidents").innerHTML = formatDisplay(current_type_2_incidents[message_num]);
document.getElementById("current_type_3_incidents").innerHTML = formatDisplay(current_type_3_incidents[message_num]);
document.getElementById("current_type_4_incidents").innerHTML = formatDisplay(current_type_4_incidents[message_num]);
document.getElementById("current_type_5_incidents").innerHTML = formatDisplay(current_type_5_incidents[message_num]);
document.getElementById("current_type_6_incidents").innerHTML = formatDisplay(current_type_6_incidents[message_num]);
document.getElementById("current_type_7_incidents").innerHTML = formatDisplay(current_type_7_incidents[message_num]);
document.getElementById("current_location_1_incidents").innerHTML = formatDisplay(current_location_1_incidents[message_num]);
document.getElementById("current_location_2_incidents").innerHTML = formatDisplay(current_location_2_incidents[message_num]);
document.getElementById("current_location_3_incidents").innerHTML = formatDisplay(current_location_3_incidents[message_num]);
document.getElementById("current_location_4_incidents").innerHTML = formatDisplay(current_location_4_incidents[message_num]);
document.getElementById("current_location_5_incidents").innerHTML = formatDisplay(current_location_5_incidents[message_num]);
document.getElementById("current_police_assignments").innerHTML = formatDisplay(current_police_assignments[message_num]);
document.getElementById("current_fire_assignments").innerHTML = formatDisplay(current_fire_assignments[message_num]);
document.getElementById("current_medical_assignments").innerHTML = formatDisplay(current_medical_assignments[message_num]);
document.getElementById("current_incident_count").innerHTML = formatDisplay(current_incident_count[message_num]);
document.getElementById("total_incident_count").innerHTML = formatDisplay(total_incident_count[message_num]);
} // function updateScoreboard()

function updateTimer() {
    // see if there are any messages to deliver.
    if (++timer == message_time[current_message]) {
        // play the audio message
        playSound("message" + current_message);
        time_since_last_message = 0;
        <?PHP if ($interface_selection == 3) { ?>
            document.getElementById("message_text").innerHTML = message_text[current_message];
        <?PHP } //if ($interface_selection == 3)?>

        // move on
        current_message++;
    } // if
    time_since_last_message++;

    document.getElementById("current_type_2_incidents").innerHTML = formatDisplay(current_type_2_incidents[message_num]);
    document.getElementById("current_type_3_incidents").innerHTML = formatDisplay(current_type_3_incidents[message_num]);
    document.getElementById("current_type_4_incidents").innerHTML = formatDisplay(current_type_4_incidents[message_num]);
    document.getElementById("current_type_5_incidents").innerHTML = formatDisplay(current_type_5_incidents[message_num]);
    document.getElementById("current_type_6_incidents").innerHTML = formatDisplay(current_type_6_incidents[message_num]);
    document.getElementById("current_type_7_incidents").innerHTML = formatDisplay(current_type_7_incidents[message_num]);
    document.getElementById("current_location_1_incidents").innerHTML = formatDisplay(current_location_1_incidents[message_num]);
    document.getElementById("current_location_2_incidents").innerHTML = formatDisplay(current_location_2_incidents[message_num]);
    document.getElementById("current_location_3_incidents").innerHTML = formatDisplay(current_location_3_incidents[message_num]);
    document.getElementById("current_location_4_incidents").innerHTML = formatDisplay(current_location_4_incidents[message_num]);
    document.getElementById("current_location_5_incidents").innerHTML = formatDisplay(current_location_5_incidents[message_num]);
    document.getElementById("current_police_assignments").innerHTML = formatDisplay(current_police_assignments[message_num]);
    document.getElementById("current_fire_assignments").innerHTML = formatDisplay(current_fire_assignments[message_num]);
    document.getElementById("current_medical_assignments").innerHTML = formatDisplay(current_medical_assignments[message_num]);
    document.getElementById("current_incident_count").innerHTML = formatDisplay(current_incident_count[message_num]);
    document.getElementById("total_incident_count").innerHTML = formatDisplay(total_incident_count[message_num]);
} // function updateScoreboard()
time_since_last_report++;

//var clock_div = document.getElementById('timer_area');
//clock_div.innerHTML = timer;

if (current_message < (message_time.length)) {
    // check if it is time for a SAGAT assessment
    if (timer == message_time[event_for_sagat]) {
        // if it is, allow time for recording updates, then jump to the assessment routine
        setTimeout("sagat_assessment()");
    } else { // pause and cycle
        setTimeout("updateTimer()");
    } // if-else
} else { // with the last message delivered, insert a delay and go to the clean-up routine
    setTimeout("cleanup()");
} // if-else
}

function sagat_assessment() {
    // save and then hide the main display
    Main_Display = document.getElementById("Main_Display").innerHTML;
    document.getElementById("Main_Display").innerHTML = "";

    // show the SAGAT assessment input form
    document.getElementById("SAGAT_Form").innerHTML = SAGAT_Form;
    playSound("sagat_message");
}

function sagat_assessment_submit(formObj) {
    stopSound("sagat_message");

    // record the SAGAT responses
    logItem("recording SAGAT responses - user <?PHP echo $user_session; ?> at message # " + current_message);

    var ActionString = 'action=sagat&user=<?PHP echo $user_session; ?>&time=' + timer;
    ActionString += '&script=<?PHP echo $script_selection; ?>&message=' + current_message;

    // send the action string to the server
    sendActionString(ActionString);
}
ActionString += '&CT1=' + formObj.type_1_estimate.value;
ActionString += '&CT2=' + formObj.type_2_estimate.value;
ActionString += '&CT3=' + formObj.type_3_estimate.value;
ActionString += '&CT4=' + formObj.type_4_estimate.value;
ActionString += '&CT5=' + formObj.type_5_estimate.value;
ActionString += '&CT6=' + formObj.type_6_estimate.value;
ActionString += '&CT7=' + formObj.type_7_estimate.value;
ActionString += '&MFT=' + eval_response(formObj.most_frequent_type);
ActionString += '&LFT=' + eval_response(formObj.least_frequent_type);
ActionString += '&CPI=' + formObj.current_police_incidents.value;
ActionString += '&CFI=' + formObj.current_fire_incidents.value;
ActionString += '&CMI=' + formObj.current_medical_incidents.value;
ActionString += '&BSO=' + eval_response(formObj.overall_busiest_service);
ActionString += '&CL1=' + formObj.location_1_estimate.value;
ActionString += '&CL2=' + formObj.location_2_estimate.value;
ActionString += '&CL3=' + formObj.location_3_estimate.value;
ActionString += '&CL4=' + formObj.location_4_estimate.value;
ActionString += '&CL5=' + formObj.location_5_estimate.value;
ActionString += '&BLC=' + eval_response(formObj.busiest_location);
ActionString += '&CIC=' + formObj.current_incident_count.value;
ActionString += '&TIC=' + formObj.total_incident_count.value;

reportAction(ActionString);
// hide the SAGAT form and bring back the main display
document.getElementById("SAGAT_Form").innerHTML = "";
document.getElementById("Main_Display").innerHTML = Main_Display;
// restart the clock and return to normal
updateTimer();
}

function cleanup() {
    // submitLog(log_text);
    document.getElementById("Main_Display").innerHTML = "";
    document.getElementById("EXIT_Form").innerHTML = EXIT_Form;
    document.getElementById("frm_Exit").log_text.value = log_text;
}

function reportAction(parameters) {
    var httpRequest;

    if (window.XMLHttpRequest) { // Mozilla, Safari, ...
        httpRequest = new XMLHttpRequest();
        if (httpRequest.overrideMimeType)
            httpRequest.overrideMimeType('text/xml');
            // See note below about this line
            } // if
    } else if (window.ActiveXObject) { // IE
        try {
            httpRequest = new ActiveXObject("Msxml2.XMLHTTP");
        } catch (e) {
            try {
                httpRequest = new ActiveXObject("Microsoft.XMLHTTP");
            } catch (e) {
            }
        }
    } else { // catch
        try {
            httpRequest = new ActiveXObject("Msxml2.XMLHTTP");
        } catch (e) {
            try {
                httpRequest = new ActiveXObject("Microsoft.XMLHTTP");
            } catch (e) {
            }
        }
    }
}
} catch (e) {
} // try-catch
} // try-catch

if (!httpRequest) {
  alert('Browser error: unable to create an XMLHttpRequest instance');
  return false;
} // if

httpRequest.onreadystatechange = function() {
  handleResponse(httpRequest);
};

httpRequest.open('GET', ('notify.php?' + parameters), true);

httpRequest.send(null);

current_report++;
total_time_from_message_to_report += time_since_last_message;
time_since_last_report = 0;

} // reportAction

function handleResponse(httpRequest) {
  if (httpRequest.readyState == 4) {
    if (httpRequest.status == 200) {
      logItem("handler response: " + httpRequest.responseText);
    } else {
      alert('There was a problem communicating with the server. Request status is ' + httpRequest.status);
    } // if-else
  } // if
} // handleResponse

function recordStatusChange(resourceObj,statusObj) {
  var resource_id = eval_response(resourceObj);
  var new_status = eval_response(statusObj);
  logItem("recording status change - user <?PHP echo $user_session; ?> resource " + resource_id + " to status " + new_status + " at time " + timer);
  reportAction('action=statuschange&user=<?PHP echo $user_session; ?>&resource=' + resource_id + '&status=' + new_status + '&time=' + timer + '&TTLM=' + time_since_last_message + '&TTLR=' + time_since_last_report);
  document.form_StatusChange.reset();
  updateScoreboard(current_message - 1);
} // recordStatusChange

function recordNewIncident(typeObj,locationObj) {
  var incident_type = eval_response(typeObj);
  var incident_location = eval_response(locationObj);
  logItem("recording new incident - user <?PHP echo $user_session; ?> type " + incident_type + " location " + incident_location + " at time " + timer);
  reportAction('action=newincident&user=<?PHP echo $user_session; ?>&type=' + incident_type + '&location=' + incident_location + '&time=' + timer + '&TTLM=' + time_since_last_message + '&TTLR=' + time_since_last_report);
  document.form_NewIncident.reset();
  updateScoreboard(current_message - 1);
} // recordNewIncident
function Filter_IntegersOnly(FieldValue) {
    // This function should be called from an onKeyUp event with a reference to the
    // current input field (ex.: onKeyUp="javascript:Filter_IntegersOnly(this)"
    // Any dis-allowed character entry will be voided, and a message displayed.
    var AllowedCharacters = "0123456789";
    if(AllowedCharacters.indexOf(FieldValue.value.charAt((FieldValue.value.length) - 1)) < 0) {
        FieldValue.value = FieldValue.value.substring(0, (FieldValue.value.length) - 1);
        alert("Input Field: \"" + FieldValue.name + \"\nOnly numeric characters are allowed here!\";
        FieldValue.focus();
    } /* end if */
} /* function */

function Verify_IntegersOnly(FieldValue) {
    // This function should be called from an onBlur event with a reference to the
    // current input field (ex.: onBlur="javascript:Verify_IntegersOnly(this)"
    // Any dis-allowed characters will be voided. This function should be used in
    // addition to the Filter_IntegersOnly() function to eliminate characters which
    // could slip through by dual key presses.
    var AllowedCharacters = "0123456789";
    for (var i=(FieldValue.value.length-1); i>=0; i--) {
        if (AllowedCharacters.indexOf(FieldValue.value.charAt(i)) < 0) {
            FieldValue.value = FieldValue.value.substring(0, i) +
            FieldValue.value.substring((i+1), FieldValue.value.length);
        } /* end if */
    } /* end for */
} /* end function */
</script>
<title>The Effects of Variation in Inter-Modal User Interface Design on
Accuracy, Timeliness, and Situation Awareness</title>
</head>

<!-- DEBUGING MESSAGES
<CENTER><TABLE WIDTH="90%" BORDER="0" CELLPACING="1" CELLPADDING="5"
ALIGN="CENTER"><TR BGCOLOR="#FF0000"><TD ALIGN="left" VALIGN="top">
<?PHP
    echo "session id # " . $user_session . "\r\n";
    echo " script # " . $script_selection . " which contains " .
    $message_num . " messages\r\n";
    echo " interface # " . $interface_selection . "\r\n";
    echo " sagat time : " . $sagat_timing . "\r\n";
?>
</TD></TR></TABLE></CENTER>
<!-- END OF DEBUGGING MESSAGES -->

<!-- END OF DEBUGGING MESSAGES -->
</BODY bgcolor="#FFFFFF" text="#000000" link="#000088" vlink="#000088"
alink="#FF0000" onLoad="startup()">
<tr><td><hr>

<table width="100%" border="0" cellspacing="0" cellpadding="0">
<tr>
<?PHP if ($interface_selection == 3) {?><td width="90%" align="center" valign="middle">
<table width="95%" border="0" cellspacing="0" cellpadding="4">
<tr><td align="left"><font size="+1"><strong><DIV ID="message_text">THIS AREA WILL SHOW THE TEXT OF MESSAGES AS THEY ARRIVE</DIV></strong></font></td></tr>
<?PHP } //if ($interface_selection == 3)?></td>
<td align="right" valign="top"><table width="200" border="0" cellspacing="1" cellpadding="2" align="center" valign="middle">
<td width="25%" bgcolor="#887777" onClick="playSound('message' + (current_message-4));"><font size="-2" color="#000000">older</font></td>
<td width="25%" bgcolor="#AA9999" onClick="playSound('message' + (current_message-3));"><font size="-2" color="#000000">older</font></td>
<td width="25%" bgcolor="#CCBBBB" onClick="playSound('message' + (current_message-2));"><font size="-2" color="#000000">previous</font></td>
<td width="25%" bgcolor="#EEDDDD" onClick="playSound('message' + (current_message-1));"><font size="-2" color="#000000">newest<br>message</font></td>
</tr></table></td>
</tr></table>
<hr>
</td></tr><tr><td bgcolor="#EEEEEE">
<table width="100%" border="0" cellspacing="0" cellpadding="0">
<tr align="left" valign="top"><td width="40%">
<table width="100%" border="0" cellspacing="2" cellpadding="5" align="left">
<form name="form_NewIncident">
<tr valign="top">
<td width="12" align="center" bgcolor="#888888"><font face="sans-serif" color="#000066">N<br>E<br>W<br>&nbsp;<br>I<br>N<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D</font></td>
<td align="left" bgcolor="#EEEEEE"><table width="100%" border="0" cellspacing="0" cellpadding="0">
<tr><td>
<table border="0" cellspacing="0" cellpadding="2">
<tr>
<td align="right">CURRENT Incident Count:</td>
<td><DIV ID="current_incident_count"><font color='#FFFFFF'>-</font></DIV></td>
</tr>
</table>
</td></tr>

</table>
</form>
</td>
</tr></table>
</tr></table>
</td></tr><tr><td bgcolor="#EEEEEE">
<table width="100%" border="0" cellspacing="0" cellpadding="0">
<tr align="left" valign="top"><td width="40%">
<table width="100%" border="0" cellspacing="2" cellpadding="5" align="left">
<form name="form_NewIncident">
<tr valign="top">
<td width="12" align="center" bgcolor="#888888"><font face="sans-serif" color="#000066">N<br>E<br>W<br>&nbsp;<br>I<br>N<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br>I<br>D<br>E<br>N<br>I<br>C<br,I<br>D</font></td>
<td align="left" bgcolor="#EEEEEE"><table width="100%" border="0" cellspacing="0" cellpadding="0">
<tr><td>
<table border="0" cellspacing="0" cellpadding="2">
<tr>
<td align="right">TOTAL Incident Count:</td>
<td><DIV ID="total_incident_count"><font color='#FFFFFF'>-</font></DIV></td>
</tr>
</table>
</td></tr>

</table>
</form>
</td>
</tr></table>
</tr></table>
</td></tr>
</table>
</tr>
<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Current Number of Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Current Number of Incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>
<!-- line-breaks on a button face work, but makes for ugly
code -->
<input type="button" style="font-family: sans-serif; font-
size: normal; font-weight: bold;" value="<?PHP echo "Click Here\nto record
this\nNEW INCIDENT"; ?>"
onClick="recordNewIncident(incident_type,location);">
</td></tr></table>
</td></tr></table>
</td>
</form>
</table>

<table width="100%" border="0" cellspacing="2" cellpadding="5" align="left">
<form action="" name="form_StatusChange">
<tr align="left" valign="top">
<td width="12" align="center" bgcolor="#888888">
<font face="sans-serif" color="#000066">
S
T
A
T
U
S
T
A
CH
A
N
G
E
</font>
</td>
<td bgcolor="#EEEEEE">
<table width="100%" border="0" cellspacing="0" cellpadding="1">
<tr><td>&nbsp;</td><td><font size="-1" color="#888888">current number of police assignments</font></td></tr>
<tr><td width="10%"><strong><u>Police</u></strong></td>
<td><DIV ID="current_police_assignments"><font color='#FFFFFF'>-</font></DIV></td>
</tr>
<tr><td align="left" <?PHP if ($interface_selection > 1) echo " bgcolor="#BBBBF"'";?>>
<table border="0" cellspacing="0" cellpadding="2"><tr
align="right" valign="top">
<?PHP
if ($interface_selection > 1)
echo"<td><img src='icons/icon_law.gif' alt='' width='100' height='100' border='0'></td>
";
else
echo"<td><img src='icons/spacer.gif' alt='' width='100' height='100' border='0'></td>
";
?>
</tr></table>
</td>
</tr>
</table>
</td>
</tr></form>
</table>

</td>
</tr></table>

237
<?php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=1 ORDER BY resource_id ASC LIMIT 5;", $db_connection) or die ("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . ">
";/label></td><tr>
}; // while still more data
</table>
</td><td>
<table border="0" cellspacing="0" cellpadding="0">
<?php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=1 ORDER BY resource_id ASC LIMIT 5,5;", $db_connection) or die ("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . ">
";/label></td><tr>
}; // while still more data
</table>
</td><td>
<table border="0" cellspacing="0" cellpadding="0">
<?php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=1 ORDER BY resource_id ASC LIMIT 10,5;", $db_connection) or die ("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . ">
";/label></td><tr>
}; // while still more data
</table>
</td><td>
<table border="0" cellspacing="0" cellpadding="0">
<?php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=1 ORDER BY resource_id ASC LIMIT 15,5;", $db_connection) or die ("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . ">
";/label></td><tr>
}; // while still more data
</table>
</td></tr></table>
<table>
<thead>
<tr>
<th>Fire</th>
<th>Current Fire Assignments</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

```php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=2 ORDER BY resource_id ASC LIMIT 5;", $db_connection) or die("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . "'><label><input type='radio' name='resource' value='" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . "</label></td></tr>
";}
```

```php
$results = mysql_query("SELECT * FROM resources WHERE resource_type=2 ORDER BY resource_id ASC LIMIT 5,5;", $db_connection) or die("Could not read data because ".mysql_error());
while ($tuple = mysql_fetch_array($results)) {
    echo "<tr><td name='resource_" . $tuple["resource_id"] . "'><label><input type='radio' name='resource' value='" . $tuple["resource_id"] . ">" . $tuple["resource_name"] . "</label></td></tr>
";}
```
New Status Setting has been dispatched
is enroute
is on scene
is available
is back at base

current number of medical assignments

Medical

<?PHP $results = mysql_query("SELECT * FROM resources WHERE resource_type=3 ORDER BY resource_id ASC LIMIT 5;", $db_connection) or die("Could not read data because ",mysql_error()); while ($tuple = mysql_fetch_array($results)) {   

Now, I'd like you to answer a few questions regarding your perception of the situation you have been following. Please fill in the values below as best as you can. If you are unsure of any value, please enter your best guess.
<table>
<thead>
<tr>
<th>Incident Type</th>
<th>Most Frequent Type</th>
<th>Least Frequent Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Police</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medical</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Region Description</td>
<td>Current Estimate</td>
<td>Busiest Region</td>
</tr>
<tr>
<td>--------------------</td>
<td>------------------</td>
<td>---------------</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How many incidents are CURRENTLY going on in each area?

What region is the BUSIEST so far?

Overall number of incidents:

Current:

Total:
<?PHP
// This sound file pre-load routine assumes a standardized file naming scheme.
// Alternatively, the sound file names could be retrieved from the database.
for ($x=1; $x<=$message_num; $x++) {
    echo '<object name="name" value="message' . $x . '">
"src" value="sound/' . $script_selection . '_' . $x . '.mp3">
"autostart" value="false">
"autoplay" value="false">
"controller" value="false">
"enablejavascript" value="true">\n"name" value="message' . $x . '"
"src" value="sound/' . $script_selection . '_' . $x . '.mp3">
"autostart" value="false" width=1 height=1 name="message' . $x . '">
"enablejavascript" value="true">\n"name" value="message' . $x . '"
"src" value="sound/sagat_message.mp3">
"autostart" value="false" width=1 height=1 name="sagat_message">
"enablejavascript" value="true">
</object>
}} // for
<br/>

<script type="text/javascript">
    Main_Display = document.getElementById("Main_Display").innerHTML;
    SAGAT_Form = document.getElementById("SAGAT_Form").innerHTML;
    document.getElementById("SAGAT_Form").innerHTML = "";
</script>
alert("It may take a minute or two to load all the pieces of this page. Please be patient. You'll see another message like this when everything is ready.");
//-->
</script>

</body>
</html>

PHP source code for file: notify.php

<?PHP

// check for illegal referrers
$referring_url  = strtoupper($_SERVER['HTTP_REFERER']);
$current_url    = "http://" . $_SERVER['HTTP_HOST'] . $_SERVER['PHP_SELF'];
$allowed_url    = strtoupper(substr($current_url,0,(1+strripos($current_url,"/"))) . "experiment.php");

if  ($referring_url == $allowed_url) {
    include "include_for_database_access.php";
    $db_connection = connect_to_mysql();

    $action = stripslashes($_REQUEST['action']);
    $user = stripslashes($_REQUEST['user']);
    $time = stripslashes($_REQUEST['time']);
    $time_since_last_message = stripslashes($_REQUEST['TTLM']);
    $time_since_last_report = stripslashes($_REQUEST['TTLR']);

    echo("message received");
    echo(" from user " . $user);
    echo(" at time " . $time);
    echo(" for " . $action);

    if ($action == "begin") {

    } else if ($action == "newincident") {

        $type = (!isset($_REQUEST['type']) ? "NULL" :stripslashes($_REQUEST['type']));
        $location = (!isset($_REQUEST['location']) ? "NULL" :stripslashes($_REQUEST['location']));


}
$type . "", "", "$location . "", "$time_since_last_message . "", "$time_since_last_report . ");

//write to the DB
if ($db_connection != 0) {
    $results = mysql_query($sql, $db_connection) or die ("Could not write data because: " . mysql_error() . "   SQL: " . $sql);
} else {
    echo "problem with DB connection<BR>
";
}
// if-else DB connection
echo(" type ". $type);
echo(" location ". $location);

} else if ($action == "statuschange") {

    $resource = (!isset($_REQUEST['resource']) ? "NULL" : stripslashes($_REQUEST['resource']));
    $status = (!isset($_REQUEST['status']) ? "NULL" : stripslashes($_REQUEST['status']));
    $sql  = "INSERT INTO reported_changes (" .
            "session_id, " .
            "report_time, " .
            "resource, " .
            "new_status, " .
            "time_since_last_announcement, " .
            "time_since_last_report" .
            ") VALUES (" .
            "$user . ", 
            "$time . ",
            "$resource . " .
            "$status . ",
            "$time_since_last_message . ", 
            "$time_since_last_report . ");"
;
    //write to the DB
if ($db_connection != 0) {
    $results = mysql_query($sql, $db_connection) or die ("Could not write data because: " . mysql_error() . "   SQL: " . $sql);
} else {
    echo "problem with DB connection<BR>
";
}
// if-else DB connection
echo(" resource ". $resource);
echo(" status ". $status);

} else if ($action == "sagat") {

    $script = ($_REQUEST['script'] == "") ? "NULL" : stripslashes($_REQUEST['script']);
    $message = ($_REQUEST['message'] == "") ? "NULL" : stripslashes($_REQUEST['message']);
    $CT1 = ($_REQUEST['CT1'] == "") ? "NULL" : stripslashes($_REQUEST['CT1']);
    $CT2 = ($_REQUEST['CT2'] == "") ? "NULL" : stripslashes($_REQUEST['CT2']);
}
$CT3 = ($_REQUEST['CT3'] == '') ? "NULL" : stripslashes($_REQUEST['CT3']);
$CT4 = ($_REQUEST['CT4'] == '') ? "NULL" : stripslashes($_REQUEST['CT4']);
$CT5 = ($_REQUEST['CT5'] == '') ? "NULL" : stripslashes($_REQUEST['CT5']);
$CT6 = ($_REQUEST['CT6'] == '') ? "NULL" : stripslashes($_REQUEST['CT6']);
$CT7 = ($_REQUEST['CT7'] == '') ? "NULL" : stripslashes($_REQUEST['CT7']);
$MFT = ($_REQUEST['MFT'] == '') ? "NULL" : stripslashes($_REQUEST['MFT']);
$LFT = ($_REQUEST['LFT'] == '') ? "NULL" : stripslashes($_REQUEST['LFT']);
$CPI = ($_REQUEST['CPI'] == '') ? "NULL" : stripslashes($_REQUEST['CPI']);
$CFI = ($_REQUEST['CFI'] == '') ? "NULL" : stripslashes($_REQUEST['CFI']);
$CMI = ($_REQUEST['CMI'] == '') ? "NULL" : stripslashes($_REQUEST['CMI']);
$BSC = ($_REQUEST['BSC'] == '') ? "NULL" : stripslashes($_REQUEST['BSC']);
$BSO = ($_REQUEST['BSO'] == '') ? "NULL" : stripslashes($_REQUEST['BSO']);
$CL1 = ($_REQUEST['CL1'] == '') ? "NULL" : stripslashes($_REQUEST['CL1']);
$CL2 = ($_REQUEST['CL2'] == '') ? "NULL" : stripslashes($_REQUEST['CL2']);
$CL3 = ($_REQUEST['CL3'] == '') ? "NULL" : stripslashes($_REQUEST['CL3']);
$CL4 = ($_REQUEST['CL4'] == '') ? "NULL" : stripslashes($_REQUEST['CL4']);
$CL5 = ($_REQUEST['CL5'] == '') ? "NULL" : stripslashes($_REQUEST['CL5']);
$BLC = ($_REQUEST['BLC'] == '') ? "NULL" : stripslashes($_REQUEST['BLC']);
$CIC = ($_REQUEST['CIC'] == '') ? "NULL" : stripslashes($_REQUEST['CIC']);
$TIC = ($_REQUEST['TIC'] == '') ? "NULL" : stripslashes($_REQUEST['TIC']);

$sql = "INSERT INTO sagat_responses (" .
    "session_id, " .
    "script, " .
    "message, " .
    "CT1, " .
    "CT2, " .
    "CT3, " .
    "CT4, " .
    "CT5, " .
    "CT6, " .
    "CT7, " .
    "MFT, " .
    "LFT, " .
    "CPI, " .
    "CFI, " .
    "CMI, " .
    "BSC, " .
    "BSO, " .
    "CL1, " .
    "CL2, " .
    "CL3, " .
    "CL4, " .
    "CL5, " .
    "BLC, " .
    "CIC, " .
    "TIC) VALUES (" .
    "'" .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
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    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    "' .
    ");" .

echo $sql;
"CL2, " .
"CL3, " .
"CL4, " .
"CL5, " .
"BLC, " .
"CIC, " .
"TIC " .
") VALUES ("
$user . 
$script . 
$message . 
$CT1 . 
$CT2 . 
$CT3 . 
$CT4 . 
$CT5 . 
$CT6 . 
$CT7 . 
$MFT . 
$SLFT . 
$CPI . 
$CFI . 
$CMI . 
$BSN . 
$BSO . 
$CL1 . 
$CL2 . 
$CL3 . 
$CL4 . 
$CL5 . 
$BLC . 
$CIC . 
$TIC . 
") ;

//write to the DB
if ($db_connection != 0) {
  $results = mysql_query($sql, $db_connection) or die ("Could not write data because: ". mysql_error(). " SQL: ". $sql);
} else {
  echo "problem with DB connection<BR>\n";
} // if-else DB connection

echo(" script ". $script);
echo(" message ". $message);
echo(" CT1=" . $CT1);
echo(" CT2=" . $CT2);
echo(" CT3=" . $CT3);
echo(" CT4=" . $CT4);
echo(" CT5=" . $CT5);
echo(" CT6=" . $CT6);
echo(" CT7=" . $CT7);
echo(" MFT=" . $MFT);
echo(" LFT=" . $LFT);
echo(" CPI=" . $CPI);
echo(" CFI=" . $CFI);
echo(" CMI=" . $CMI);
echo(" BSC=" . $BSN);
echo(" BSO=" . $BSO);
echo(" CL1=" . $CL1);
PHP source code for file: exit.php

```php
<?PHP
// check for illegal referrers
$referring_url  = strtoupper($_SERVER['HTTP_REFERER']);
$current_url    = "http://" . $_SERVER['HTTP_HOST'] . $_SERVER['PHP_SELF'];
$allowed_url    = strtoupper(substr($current_url,0,(1+strripos($current_url,"/"))) . "experiment.php");
if  ($referring_url != $allowed_url) header("location:error.php?desc=illegal referrer to " . $_SERVER['PHP_SELF']);

include 'include_for_database_access.php';
$db_connection = connect_to_mysql();
$sql = "INSERT INTO logs (log_text) VALUES ('" . stripslashes($_REQUEST['log_text']) . "');
if ($db_connection != 0) {
    $results = mysql_query($sql, $db_connection) or die ("Could not write data because: ". mysql_error() . " SQL: ". $sql);
} else {
    echo "problem with DB connection<BR>
};
// as a final safety, the log will be sent via e-mail as well
mail( "turtlnx@gmail.com", "log from experiment run", stripslashes($_REQUEST['log_text']));
?>

<html>
<head>
<title>The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness</title>
</head>
<body>
<hr>
Thank you for participating in my experiment. If you would like to be included in the drawings for "thank-you" gifts, please submit your e-mail address in the space below. Your name is optional; its only purpose is to keep me from having to call you "to whom it may concern."
```
<form action="thank_you.php" method="post">
<table border="0" cellspacing="2" cellpadding="2">
<tr><td>name:<br><input type="text" name="name" size="50" value="" maxlength="50"></td></tr>
<tr><td>e-mail:<br><input type="text" name="email" size="50" value="" maxlength="50"></td></tr>
<tr><td>phone:<br><input type="text" name="phone"></td></tr>
<tr><td>
<input type="hidden" name="score" value=""/>
<input type="submit" value="ADD ME TO THE DRAWINGS">
</td></tr>
</table>
</form>

PHP source code for file: thank_you.php

<?PHP

// check for illegal referrers
$referring_url  = strtoupper($_SERVER['HTTP_REFERER']);
$current_url    = "http:" . $_SERVER['HTTP_HOST'] . $_SERVER['PHP_SELF'];
$allowed_url    = strtoupper(substr($current_url,0,(1+strripos($current_url,"/"))) . "exit.php");
if  ($referring_url != $allowed_url) header("location:error.php?desc=illegal referrer to " . $_SERVER['PHP_SELF']);

include 'include_for_database_access.php';
$db_connection = connect_to_mysql();
$sql = "INSERT INTO drawing_participants (name, email, score) VALUES (" . "'" . stripslashes($_REQUEST['name']) . ", " . "'" . stripslashes($_REQUEST['email']) . ", " . "'" . stripslashes($_REQUEST['score']) . ");";
if ($db_connection != 0) {
$results = mysql_query($sql, $db_connection) or die ("Could not write data because: " . mysql_error() . " SQL: " . $sql);
} else {
    echo "problem with DB connection<BR>
};

?>

<html>
<head>
<title>The Effects of Variation in Inter-Modal User Interface Design on
Accuracy, Timeliness, and Situation Awareness</title>
</head>

<body>
<div align="center"><font size="+4" color="#000080">THANK YOU!</font></div>
<br>
Your address has been added to the pool for the drawings.

250
I will contact you by e-mail if you are selected as a winner to arrange delivery. The drawings will take place once I have collected an adequate amount of data. The current estimate for the conclusion of data collection is sometime over the summer. Thanks again for your participation.

---

Where would you like to go now?
- Google: Click here.
- PennState: Click here.
- My favorite web comic: Click here.
- A completely random website: Click here.

---

PHP source code for file: report.php

```php
<?php
include 'include_for_database_access.php';
$db_connection = connect_to_mysql();

function cell($intext) {
    $temptext  = "		<td";
    if ($intext=="") $temptext .= " bgcolor="#222222"
    $temptext .= ">
    $temptext .= $intext;
    $temptext .= "&nbsp;</td>n"
    return $temptext;
} // function cell

<html>
<head>
<title>The Effects of Variation in Inter-Modal User Interface Design on Accuracy, Timeliness, and Situation Awareness - data report</title>
</head>

<body bgcolor="#FFFFFF" text="#000000" link="#0000FF" vlink="#0000FF" alink="#FF0000"

<?php
switch (strtoupper(stripslashes($_REQUEST['view']))) {
    case "STATUS_REPORT_ERRORS":
        echo "<div align='center'><strong><u>STATUS CHANGE REPORT ERRORS</u></strong></div><br>
        <tr><td align='center' bgcolor='#DDDDFF'><font size='+2'>Where would you like to go now?</font></td></tr>
        <tr><td align='center'><input type='button' value='Google' onclick='window.location='http://www.google.com';'></td></tr>
        <tr><td align='center'><input type='button' value='PennState' onclick='window.location='http://www.psu.edu';'></td></tr>
        <tr><td align='center'><input type='button' value='My favorite web comic' onclick='window.location='http://xkcd.com';'></td></tr>
        <tr><td align='center'><input type='button' value='A completely random website' onclick='window.location='http://random.yahoo.com/bin/ryl';'></td></tr>
    </form></table>
</body>
</html>
```
<?php
if ($db_connection != 0) {
    $sql = "SELECT " .
    "reported_changes.session_id, " .
    "sessions.interface_assignment, " .
    "reported_changes.report_id, " .
    "reported_changes.report_time, " .
    "reported_changes.time_since_last_announcement, " .
    "scripts.script_time, " .
    "reported_changes.resource, " .
    "reported_changes.new_status, " .
    "resources.resource_id, " .
    "scripts.new_status " .
    "FROM " .
    "((reported_changes INNER JOIN sessions ON " .
    "reported_changes.session_id = sessions.session_id) " .
    "INNER JOIN scripts ON sessions.script_assignment = " .
    "scripts.script_id) " .
    "INNER JOIN resources ON (scripts.resource_type = " .
    "resources.resource_type) " .
    "AND (scripts.resource_id = resources.resource_name) " .
    "WHERE " .
    "((scripts.script_time)<report_time " .
    "AND (scripts.script_time)>(report_time-30)) " .
    "AND ((reported_changes.resource)<>resources.resource_id) " .
    "AND ((reported_changes.new_status)<>scripts.new_status))" .
    " ORDER BY reported_changes.session_id DESC, reported_changes.report_id DESC, scripts.script_time DESC" .
    ";"
    $results = mysql_query($sql, $db_connection) or die ("Could not read data because: ". mysql_error() . " SQL: ". $sql);
    while ($tuple = mysql_fetch_array($results)) {
        echo "" .
        "<tr align='right' valign='top'>" .
        "<td bgcolor='#DDDDDD'>" .
        echo "\" .
        "session_id\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "interface_assignment\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "report_id\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "report_time\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "time_since_last_announcement\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "script_time\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "resource\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "new_status\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "resource_id\" .
        "</td>" .
        "<td>" .
        echo "\" .
        "new_status\" .
        "</td>" .
        "</tr>" .
    }
}
case "INCIDENT_REPORT_ERRORS":
    echo "<div align='center'><strong><u>INCIDENT REPORT ERRORS</u></strong></div><br>
    <table border='1' cellspacing='0' cellpadding='2' align='center'>
        <tr align='right' bgcolor='#DDDDDD'>
            <td><strong>session_id</strong></td>
            <td><strong>interface</strong></td>
            <td><strong>report_id</strong></td>
            <td><strong>report_time</strong></td>
            <td><strong>time_since_last_announcement</strong></td>
            <td><strong>reported_incident_type</strong></td>
            <td><strong>reported_incident_location</strong></td>
            <td><strong>script_time</strong></td>
            <td><strong>scripts_incident_type</strong></td>
            <td><strong>scripts_incident_location</strong></td>
        </tr>
        if ($db_connection != 0) {
            $sql = "SELECT " .
                "reported_changes.session_id, " .
                "sessions.interface_assignment, " .
                "reported_changes.report_id, " .
                "reported_changes.report_time, " .
                "reported_changes.time_since_last_announcement, " .
                "reported_changes.incident_type, " .
                "reported_changes.incident_location, " .
                "scripts.script_time, " .
                "scripts.incident_type, " .
                "scripts.incident_location" .
            "FROM " .
            "(reported_changes " .
            "INNER JOIN sessions ON reported_changes.session_id = sessions.session_id) " .
            "INNER JOIN scripts ON sessions.script_assignment = scripts.script_id " .
            "WHERE " .
            "(((reported_changes.incident_type) Is Not Null " .
            "AND (reported_changes.incident_type)=scripts.incident_type) " .
            "AND (((reported_changes.incident_location) Is Not Null " .
        } // if DB connection
    break;
    echo "</table>";
    if ($db_connection != 0) {
        $sql = "SELECT " .
            "reported_changes.session_id, " .
            "sessions.interface_assignment, " .
            "reported_changes.report_id, " .
            "reported_changes.report_time, " .
            "reported_changes.time_since_last_announcement, " .
            "reported_changes.incident_type, " .
            "reported_changes.incident_location, " .
            "scripts.script_time, " .
            "scripts.incident_type, " .
            "scripts.incident_location" .
        "FROM " .
        "(reported_changes " .
        "INNER JOIN sessions ON reported_changes.session_id = sessions.session_id) " .
        "INNER JOIN scripts ON sessions.script_assignment = scripts.script_id " .
        "WHERE " .
        "(((reported_changes.incident_type) Is Not Null " .
        "AND (reported_changes.incident_type)=scripts.incident_type) " .
        "AND (((reported_changes.incident_location) Is Not Null " .
    } // while still more data
(reported_changes.incident_location)<>scripts.incident_location) " .
"AND ((scripts.script_time)<report_time " .
"AND (scripts.script_time)>(report_time-30)) " .
"AND ((scripts.resource_type)=0)) " .
"ORDER BY " .
"reported_changes.session_id DESC, " .
"reported_changes.report_id DESC" .
"
$results = mysql_query($sql, $db_connection) or die ("Could not read
data because: " . mysql_error() . " SQL: " . $sql);

while ($tuple = mysql_fetch_array($results)) {
    echo "\"\t<tr align='right'><\n\t\t<td>" .
    echo $tuple["session_id"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["interface_assignment"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["report_id"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["report_time"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["time_since_last_announcement"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["script_element_id"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["script_time"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["incident_type"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["incident_location"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["incident_type"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["incident_location"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["script_time"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["time_since_last_announcement"] .
    echo "&nbsp;</td>\n\t\t<td>" .
    echo $tuple["announce_to_report_time"] .
    echo "&nbsp;</td>\n\t\t<td>\"\n"
}

if DB connection

} // while still more data

} // if DB connection

break;

case "VALID_STATUS_REPORTS":
    echo "<div align='center'><strong><u>VALIDATED STATUS CHANGE
REPORTS</u></strong></div><br>" .
    echo "<table border='1' cellspacing='0' cellpadding='2' align='center'>" .
    echo "\"\t<tr align='right' bgcolor='#DDDDDD'>" .
    echo "\"\t\t<td><strong>session_id</strong></td>" .
    echo "\"\t\t<td><strong>interface_assignment</strong></td>" .
    echo "\"\t\t<td><strong>report_id</strong></td>" .
    echo "\"\t\t<td><strong>report_time</strong></td>" .
    echo "\"\t\t<td><strong>script_element_id</strong></td>" .
    echo "\"\t\t<td><strong>script_time</strong></td>" .
    echo "\"\t\t<td><strong>incident_type</strong></td>" .
    echo "\"\t\t<td><strong>incident_location</strong></td>" .
    echo "\"\t\t<td><strong>incident_type</strong></td>" .
    echo "\"\t\t<td><strong>incident_location</strong></td>" .
    echo "\"\t\t<td><strong>incident_type</strong></td>" .
    echo "\"\t\t<td><strong>incident_location</strong></td>" .
    echo "\"\t\t<td><strong>script_time</strong></td>" .
    echo "\"\t\t<td><strong>time_since_last_announcement</strong></td>" .
    echo "\"\t\t<td><strong>announce_to_report_time</strong></td>" .
    echo "\"\t</tr>\n" ;
```php
if ($db_connection != 0) {
    $sql = "SELECT " .
    "sessions.session_id, " .
    "reported_changes.report_id, " .
    "scripts.script_element_id, " .
    "scripts.script_time, " .
    "reported_changes.time_since_last_announcement, " .
    "(report_time-script_time) AS announce_to_report_time " .
    "FROM " .
    "((reported_changes " .
    "INNER JOIN sessions ON reported_changes.session_id = " .
    "sessions.session_id) " .
    "INNER JOIN sessions ON (reported_changes.new_status = " .
    "scripts.new_status) " .
    "AND (sessions.script_assignment = scripts.script_id)) " .
    "INNER JOIN resources ON (reported_changes.resource = " .
    "resources.resource_id) " .
    "AND (scripts.resource_id = resources.resource_name) " .
    "AND (scripts.resource_type = resources.resource_type) " .
    "WHERE " .
    "((scripts.script_time<report_time) " .
    "AND ((report_time-script_time)<30) " .
    "AND (scripts.resource_type>0)) " .
    "ORDER BY " .
    "reported_changes.session_id DESC, " .
    "reported_changes.report_id DESC " .
    ";";
    $results = mysql_query($sql, $db_connection) or die ("Could not read data because: " . mysql_error() . " SQL: " . $sql);
    
    while ($tuple = mysql_fetch_array($results)) {
        echo "\t<tr align='right'><td>
        echo $tuple['session_id'];
        echo "\n\t\t<td>" .
        echo $tuple['interface_assignment'];
        echo "\n\t\t<td>" .
        echo $tuple['report_id'];
        echo "\n\t\t<td>" .
        echo $tuple['report_time'];
        echo "\n\t\t<td>" .
        echo $tuple['script_element_id'];
        echo "\n\t\t<td>" .
        echo $tuple['script_time'];
        echo "\n\t\t<td>" .
        echo $tuple['time_since_last_announcement'];
        echo "\n\t\t<td>" .
        echo $tuple['announce_to_report_time'];
        echo "\n\t\t</td>" .
    } // while still more data
} // if DB connection
```

255
break;

case "VALID_INCIDENT_REPORTS":

echo "<div align='center'><strong><u>VALIDATED NEW INCIDENT REPORTS</u></strong></div><br>";

if ($db_connection != 0) {
    $sql = "SELECT " .
            "reported_changes.session_id, " .
            "sessions.interface_assignment, " .
            "reported_changes.report_id, " .
            "reported_changes.report_time, " .
            "scripts.script_element_id, " .
            "scripts.script_time, " .
            "reported_changes.time_since_last_announcement, " .
            "(report_time-script_time) AS announce_to_report_time " .
            "FROM " .
            "(reported_changes " .
            "INNER JOIN sessions ON reported_changes.session_id = sessions.session_id) " .
            "INNER JOIN scripts ON (reported_changes.incident_location = scripts.incident_location) " .
            "AND " .
            "(reported_changes.incident_type = scripts.incident_type) " .
            "AND " .
            "(sessions.script_assignment = scripts.script_id) " .
            "WHERE " .
            "((scripts.script_time<report_time) " .
            "AND " .
            "((report_time-script_time)<30) " .
            "AND " .
            "(scripts.resource_type=0)) " .
            "ORDER BY " .
            "session_id DESC, " .
            "report_id DESC " .
            ";";

    $results = mysql_query($sql, $db_connection) or die("Could not read data because: ". mysql_error() ." SQL:").$sql);

    while ($tuple = mysql_fetch_array($results)) {
        echo "\t<tr align='right'>\n\t\t<td>" .
        echo $tuple["session_id"];
        echo "&nbsp;</td>\n\t\t<td>";
    }
}
```php
$tuple = array() {
    "interface_assignment",
    "report_id",
    "report_time",
    "script_element_id",
    "script_time",
    "time_since_last_announcement",
    "announce_to_report_time",
};

echo $tuple["interface_assignment"];
echo "&nbsp;</td>
<td>
echo $tuple["report_id"];
echo "&nbsp;</td>
<td>
echo $tuple["report_time"];
echo "&nbsp;</td>
<td>
echo $tuple["script_element_id"];
echo "&nbsp;</td>
<td>
echo $tuple["script_time"];
echo "&nbsp;</td>
<td>
echo $tuple["time_since_last_announcement"];
echo "&nbsp;</td>
<td>
echo $tuple["announce_to_report_time"];
};

} // while still more data

} // if DB connection

echo "</table>";

break;

case "REPORTS":

    echo "<div align='center'><strong><u>RAW REPORT-BACKS</u></strong></div><br>
    
    echo "<table border='1' cellspacing='0' cellpadding='2' align='center'>

    echo "	<tr align='right' bgcolor='#DDDDDD'>

    echo "		<td><strong>session_id</strong></td>
    echo "		<td><strong>script</strong></td>
    echo "		<td><strong>report_time</strong></td>
    echo "		<td><strong>incident_type</strong></td>
    echo "		<td><strong>incident_location</strong></td>
    echo "		<td><strong>resource</strong></td>
    echo "		<td><strong>new_status</strong></td>
    echo "	</tr>

    if ($db_connection != 0) {
        $sql = "SELECT " .
      "report_id, " .
      "reported_changes.session_id, " .
      "script_assignment, " .
      "report_time, " .
      "incident_type, " .
      "incident_location, " .
      "resource, " .
      "new_status " .
      "FROM " .
      "reported_changes " .
      "JOIN sessions ON " .
      "reported_changes.session_id=sessions.session_id " .
      "ORDER BY reported_changes.session_id DESC, report_id ASC " .
      ";
    
    $results = mysql_query($sql, $db_connection) or die ("Could not read data because: " . mysql_error() . " SQL: " . $sql);
```

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while ($tuple = mysql_fetch_array($results)) {

echo "\t<tr align='right'>\n\t	<td>
" . $tuple['session_id'] . "&nbsp;</td>
\t	<td>
" . $tuple['script_assignment'] . "&nbsp;</td>
\t	<td>
" . $tuple['report_time'] . "&nbsp;</td>
\t	<td>
" . $tuple['incident_type'] . "&nbsp;</td>
\t	<td>
" . $tuple['incident_location'] . "&nbsp;</td>
\t	<td>
" . $tuple['resource'] . "&nbsp;</td>
\t	<td>
" . $tuple['new_status'] . "&nbsp;</td>
\t</tr>
";
} // while still more data
}// if DB connection

echo "</table>";
break;

case "SESSIONS":
    echo "<div align='center'><strong><u>SESSION DATA</u></strong></div><br>";
    echo "<table border='1' cellspacing='0' cellpadding='2' align='center'>";
    echo "\t<tr align='right' bgcolor='#DDDDDD'>";
    echo "\t	<td><strong>session_id</strong></td>";
    echo "\t	<td><strong>report_count</strong></td>";
    echo "\t	<td><strong>session_start_time</strong></td>";
    echo "\t	<td><strong>ip_address</strong></td>";
    echo "\t	<td><strong>script_assignment</strong></td>";
    echo "\t	<td><strong>interface_assignment</strong></td>";
    echo "\t	<td><strong>sagat_timing</strong></td>";
    echo "\t	<td><strong>age_cat</strong></td>";
    echo "\t	<td><strong>gender</strong></td>";
    echo "\t	<td><strong>hearing_problems</strong></td>";
    echo "\t	<td><strong>vision_problems</strong></td>";
    echo "\t	<td><strong>movement_problems</strong></td>";
    echo "\t	<td><strong>prior_experience</strong></td>";
    echo "\t	<td><strong>computer_time</strong></td>";
    echo "\t	<td><strong>video_games</strong></td>";
    echo "\t	<td><strong>student_semester</strong></td>";
    echo "\t	<td><strong>student_gpa</strong></td>";
    echo "\t	<td><strong>student_major</strong></td>";
    echo "\t	<td><strong>CogStyle_Score</strong></td>";
    echo "\t	<td><strong>CT1</strong></td>";
    echo "\t	<td><strong>CT2</strong></td>";
    echo "\t	<td><strong>CT3</strong></td>";
    echo "\t	<td><strong>CT4</strong></td>";
    echo "\t	<td><strong>CT5</strong></td>";
    echo "\t	<td><strong>CT6</strong></td>";
    echo "\t	<td><strong>CT7</strong></td>";
<table>
<thead>
<tr>
<th>CL1</th>
<th>CL2</th>
<th>CL3</th>
<th>CL4</th>
<th>CL5</th>
<th>BSC</th>
<th>BSO</th>
<th>CL1</th>
<th>CL2</th>
<th>CL3</th>
<th>CL4</th>
<th>CL5</th>
<th>BLC</th>
<th>CIC</th>
<th>TIC</th>
</tr>
</thead>
</table>

```php
if ($db_connection != 0) {
    $sql = "SELECT " .
        "sessions.session_id, " .
        "Count(reported_changes.report_id) AS ReportCount, " .
        "sessions.session_start_time, " .
        "sessions.participant_IP_address, " .
        "sessions.script_assignment, " .
        "sessions.interface_assignment, " .
        "sessions.sagat_timing, " .
        "demographics.age_cat, " .
        "demographics.gender, " .
        "demographics.hearing_problems, " .
        "demographics.vision_problems, " .
        "demographics.movement_problems, " .
        "demographics.prior_experience, " .
        "demographics.computer_time, " .
        "demographics.video_games, " .
        "demographics.student_semester, " .
        "demographics.student_gpa, " .
        "demographics.student_major, " .
        "demographics.CogStyle_Score, " .
        "sagat_responses.CT1, " .
        "sagat_responses.CT2, " .
        "sagat_responses.CT3, " .
        "sagat_responses.CT4, " .
        "sagat_responses.CT5, " .
        "sagat_responses.CT6, " .
        "sagat_responses.CT7, " .
        "sagat_responses.MFT, " .
        "sagat_responses.LFT, " .
        "sagat_responses.CPI, " .
        "sagat_responses.CFI, " .
        "sagat_responses.CMI, " .
        "sagat_responses.BSC, " .
        "sagat_responses.BSO, " .
        "sagat_responses.CL1, " .
        "sagat_responses.CL2, " .
        "sagat_responses.CL3, " .
        "sagat_responses.CL4, " .
        "sagat_responses.CL5, " .
        "sagat_responses.BLC, " .
        "sagat_responses.CIC, " .
```
"sagat_responses.TIC ".
"FROM ((sessions ".
    "LEFT JOIN sagat_responses ON sessions.session_id = sagat_responses.session_id ".
    "LEFT JOIN demographics ON sessions.session_id = demographics.session_id ".
    "INNER JOIN reported_changes ON sessions.session_id = reported_changes.session_id ".
"HAVING (((Count(reported_changes.report_id))>10)) ".
"ORDER BY sessions.session_id DESC ".
"");
$results = mysql_query($sql, $db_connection) or die ("Could not read data because:"); SQL: "$sql");

while ($tuple = mysql_fetch_array($results)) {
    echo "	<tr align='right'>\n";
    echo cell($tuple['session_id']);
    echo cell($tuple['ReportCount']);
    echo cell($tuple['session_start_time']);
    echo cell($tuple['participant_IP_address']);
    echo cell($tuple['script_assignment']);
    echo cell($tuple['interface_assignment']);
    echo cell($tuple['sagat_timing']);
    echo cell($tuple['age_cat']);
    echo cell($tuple['gender']);
    echo cell($tuple['hearing_problems']);
    echo cell($tuple['vision_problems']);
    echo cell($tuple['movement_problems']);
    echo cell($tuple['prior_experience']);
    echo cell($tuple['computer_time']);
    echo cell($tuple['video_games']);
    echo cell($tuple['student_semester']);
    echo cell($tuple['student_gpa']);
    echo cell($tuple['student_major']);
    echo cell($tuple['CogStyle_Score']);
    echo cell($tuple['CT1']);
    echo cell($tuple['CT2']);
    echo cell($tuple['CT3']);
    echo cell($tuple['CT4']);
    echo cell($tuple['CT5']);
    echo cell($tuple['CT6']);
    echo cell($tuple['CT7']);
    echo cell($tuple['MFT']);
    echo cell($tuple['LFT']);
    echo "\n";
}
```php
$tuple = $data[0];

if ($db_connection != 0) {
    $sql = "SELECT 
            "count(session_id) AS session_count, ".
            "interface_assignment, session_start_time, ".
            "SUM((DATE_SUB(CURDATE(), INTERVAL 12 HOUR) <= session_start_time) IS TRUE) AS new_session_count ".
            "FROM 
            "(
            "HAVING (((Count(reported_changes.report_id))>10)) " .
    
```
") AS session_table ".
"GROUP BY interface_assignment ".
"ORDER BY interface_assignment ASC ".
";

$results = mysql_query($sql, $db_connection) or die ("Could not read
data because: ". mysql_error() . " SQL: ". $sql);

$returns = mysql_query($sql, $db_connection) or die ("Could not read
data because: ". mysql_error() . " SQL: ". $sql);

echo "<table border='0' cellspacing='0' cellpadding='1'
align='center'>\n";
echo "<tr><td bgcolor='#DDDDDD'><strong>session count by
interface type</strong></td></tr>
";
while ($tuple = mysql_fetch_array($results)) {
  echo "<tr>
  <td bgcolor='#DDDDDD' align='right'><strong>
  "$tuple['interface_assignment']"
  </strong></td>
  <td align='left'><table border='0' cellspacing='0'
cellpadding='0' align='left'><tr align='middle' valign='middle'>
  <td width='3*($tuple['session_count']-
  $tuple['new_session_count'])' bgcolor='#000088'>&nbsp;&nbsp;</td>
  <td align='left' width='3*$tuple['new_session_count']' bgcolor='#008800'>
    \font color='#FFFFFF'>".
  "$tuple['new_session_count']</font"></td>
  <td>&nbsp;&nbsp;<strong>$tuple['session_count']</strong></td></tr></table></td>
  </tr>
";
}
while ($tuple = mysql_fetch_array($results)) {
  echo "<tr>
  <td bgcolor='#DDDDDD' align='right'><strong>
  "$tuple['interface_assignment']"
  </strong></td>
  <td align='left'><table border='0' cellspacing='0'
cellpadding='0' align='left'><tr align='middle' valign='middle'>
  <td width='3*($tuple['session_count']-
  $tuple['new_session_count'])' bgcolor='#000088'>&nbsp;&nbsp;</td>
  <td align='left' width='3*$tuple['new_session_count']' bgcolor='#008800'>
    \font color='#FFFFFF'>".
  "$tuple['new_session_count']</font"></td>
  <td>&nbsp;&nbsp;<strong>$tuple['session_count']</strong></td></tr></table></td>
  </tr>
";
}
// while still more data
if DB connection
  echo "<tr><td colspan=2><hr></td></tr>
";
// switch $_REQUEST['VIEW']
  echo "<div align='center'>as of " . date('D @ H:i:s') . "</div><hr>
";
</table>
<form action="" method='post'>
  <table border='0' cellspacing='0' cellpadding='2' align='center'>
    <tr align='center'><td><input type="submit" value="sessions"
onClick='this.form.view.value="sessions"'></td>
    <tr align='center'><td><input type="submit" value="raw report-backs"
onClick='this.form.view.value="reports"'></td>
    <tr align='center'><td><input type="submit" value="validated report-backs"
onClick='this.form.view.value="VALID_REPORT_BACKS"'></td>
    <tr align='center'><td><input type="submit" value="incident report errors"
onClick='this.form.view.value="INCIDENT_REPORT_ERRORS"'></td>
    <tr align='center'><td><input type="submit" value="status report errors"
onClick='this.form.view.value="STATUS_REPORT_ERRORS"'></td>
    <tr align='center'><td><input type="hidden" name="view" value=""/>
  </table>
</form>
APPENDIX G – SAS ANALYSIS PROCEDURE SOURCE CODE

NOTE: Data had been previously imported to static SAS datasets for these procedures.

ods html file = '~/experiment_analysis.html';

/****** start with a straightforward breakdown of the various demographics ******/
proc freq data=sasuser.session_data;
title;
tables gender;
tables interface;
tables age_cat;
tables computer_time;
tables video_games;
tables cogstyle;
run;

/****** and some basic descriptives ******/
proc univariate data=sasuser.session_data;
title 'hours of computer use per day';
var computer_time;
histogram computer_time;
qqplot computer_time;
run;
proc univariate data=sasuser.session_data;
title 'cognitive style';
var cogstyle;
histogram cogstyle;
qqplot cogstyle;
run;

/****** can we prove that men and women have different cognitive styles? ******/
proc ttest data=sasuser.session_data;
class gender;
var cogstyle;
title 'cogstyle by gender';
run;

/****** check that there are valid differences between the slow and fast period measurements ******/
proc ttest data=sasuser.session_data;
class slow_period_mean_time_to_report;
model fast_period_mean_time_to_report = slow_period_mean_time_to_report;
title 'comparing slow and fast periods meand times to report';
run;

/****** take a look at some summary data broken down by interface ******/
proc tabulate data=sasuser.session_data;
   title;
   class interface;
   var slow_period_mean_time_to_report;
   table interface,slow_period_mean_time_to_report*(mean std n);
run;
proc tabulate data=sasuser.session_data;
   title;
   class interface;
   var fast_period_mean_time_to_report;
   table interface,fast_period_mean_time_to_report*(mean std n);
run;

/***** okay... time to look at some ANOVAs *****/
/***** first: timing comparisons *****/
proc glm data=sasuser.session_data;
   title 'compare slow period report timing across predictors';
   class interface;
   model slow_period_mean_time_to_report =
        interface|cogstyle|computer_time|video_games|gender;
run;
proc glm data=sasuser.session_data;
   title 'compare fast period report timing across predictors';
   class interface;
   model fast_period_mean_time_to_report =
        interface|cogstyle|computer_time|video_games|gender;
run;

/***** next: accuracy measures *****/
proc glm data=sasuser.session_data;
   title 'compare valid report ratio across predictors';
   class interface;
   model valid_reports_ratio =
        interface|cogstyle|computer_time|video_games|gender;
run;
proc glm data=sasuser.session_data;
   title 'compare invalid report ratio across predictors';
   class interface;
   model invalid_reports_ratio =
        interface|cogstyle|computer_time|video_games|gender;
run;
proc glm data=sasuser.session_data;
   title 'compare valid-invalid ratio across predictors';
   class interface;
   model valid_invalid_ratio =
        interface|cogstyle|computer_time|video_games|gender;
run;

/***** and finally: situation awareness *****/
proc glm data=sasuser.session_data;
   title 'compare SA Level 1 accuracy across interfaces';
   class interface;
   model SA_one_accuracy =
        interface|cogstyle|computer_time|video_games|gender;
run;
proc glm data=sasuser.session_data;
  title 'compare SA Level 1 mean errors across interfaces';
  class interface;
  model SA_one_mean_error =
    interface|cogstyle|computer_time|video_games|gender;
run;

proc glm data=sasuser.session_data;
  title 'compare SA Level 2 accuracy across interfaces';
  class interface;
  model SA_two_accuracy =
    interface|cogstyle|computer_time|video_games|gender;
run;

/* run some ANOVA against the raw timing data */
proc glm data=sasuser.timing_data;
  title 'compare report timing across interfaces';
  class interface;
  model report_delay =
    cogstyle sitcomp computer_time video_games gender
age_cat;
run;

proc glm data=sasuser.timing_data;
  title 'compare report timing across experiment groups';
  class xg;
  model report_delay =
    cogstyle|sitcomp|computer_time|video_games|gender|age_cat;
run;

proc glm data=sasuser.timing_data;
  title 'compare report timing across experiment groups';
  class xg;
  model report_delay =
    cogstyle sitcomp computer_time video_games gender
age_cat;
run;

ods html close;
### APPENDIX H – ANALYSIS PROGRAM OUTPUT (HTML GENERATED BY SAS & EDITED FOR APPEARANCE)

The FREQ Procedure

<table>
<thead>
<tr>
<th>gender</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Frequency</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>82</td>
<td>73.21</td>
<td>82</td>
<td>73.21</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
<td>26.79</td>
<td>112</td>
<td>100.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>interface</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Frequency</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>30</td>
<td>26.79</td>
<td>30</td>
<td>26.79</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>35.71</td>
<td>70</td>
<td>62.50</td>
</tr>
<tr>
<td>3</td>
<td>42</td>
<td>37.50</td>
<td>112</td>
<td>100.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>age_cat</th>
<th>Frequency</th>
<th>Percent</th>
<th>Cumulative Frequency</th>
<th>Cumulative Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>90</td>
<td>80.36</td>
<td>90</td>
<td>80.36</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>8.93</td>
<td>100</td>
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The UNIVARIATE Procedure
Variable: computer_time

Moments

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Basic Statistical Measures

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The UNIVARIATE Procedure
Variable: computer_time
hours of computer use per day

The UNIVARIATE Procedure
Variable: computer_time
cognitive style

The UNIVARIATE Procedure
Variable: cogstyle

Moments

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hours of computer use per day
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**Quantiles (Definition 5)**

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The UNIVARIATE Procedure
Variable: cogstyle
The TTEST Procedure

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compare slow period report timing across predictors

The GLM Procedure

Class Level Information

Class Levels Values
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Number of Observations Read 112
Number of Observations Used 106

compare slow period report timing across predictors

The GLM Procedure

Dependent Variable: slow_period_mean_time_to_report

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cogstyle*interface 2 14.52804504 7.26402252 3.12 0.0511
computer_time 1 7.01696438 7.01696438 3.01 0.0875
computer_t*interface 2 8.18322339 4.09161701 1.76 0.1810
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cogsty*comput*interf 2 10.05066404 5.02533202 2.16 0.1241
video_games 1 2.24989944 2.24989944 0.97 0.3295
video_game*interface 2 1.62538270 0.81269135 0.35 0.7068
cogstyle*video_games 1 9.83205605 9.83205605 4.22 0.0441
cogsty*video_*interf 2 6.78066493 3.39033246 1.46 0.2410
computer_*video_game 1 3.06842185 3.06842185 1.32 0.2554
comput*video_*interf 2 3.66817706 1.83408853 0.79 0.4595
cogsty*comput*video_ 1 13.95275554 13.95275554 5.99 0.0172
cogs*comp*vide*inter 2 10.67667993 5.33833997 2.29 0.1095
gender 1 2.84593734 2.84593734 1.22 0.2732
gender*interface 1 4.55826870 4.55826870 1.96 0.1668
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The GLM Procedure

Class Level Information
Class          Levels Values
interface      3     1 2 3

Number of Observations Read 112
Number of Observations Used  93

The GLM Procedure

Dependent Variable: fast_period_mean_time_to_report

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R-Square          Coeff Var Root MSE  fast_period_mean_time_to_report Mean
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compare fast period report timing across predictors
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comput*_video_interf 2 2.37776950 1.1888475 0.84 0.4384
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cogs*comp*_vide_interf 2 6.59684346 3.29842173 2.33 0.1080
gender 1 0.44868954 0.44868954 0.32 0.5763
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cogstyle*gender 1 0.42623163 0.42623163 0.30 0.5860
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The GLM Procedure

Class Level Information

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Number of Observations Read 112
Number of Observations Used 112

The GLM Procedure

Dependent Variable: VALID_REPORTS_RATIO

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R-Square  Coef Var  Root MSE  VALID_REPORTS_RATIO Mean
0.473052  35.41537  19.58742  55.30768

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compare invalid report ratio across predictors

The GLM Procedure

Class Level Information
Class Levels Values
interface 3 1 2 3

Number of Observations Read 112
Number of Observations Used 112

compare invalid report ratio across predictors

The GLM Procedure

Dependent Variable: INVALID_REPORTS_RATIO

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R-Square  Coeff Var  Root MSE  INVALID_REPORTS_RATIO Mean
0.408131  30.36020  8.297876  27.33143

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The GLM Procedure

Class Level Information

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video_games*gender | 1 | 35.7223533 | 35.7223533 | 0.52 | 0.4739
video_*gender*interf | 2 | 19.1561920 | 9.5780960 | 0.14 | 0.8704
cogsty*video_*gender | 1 | 9.4778222 | 9.4778222 | 0.14 | 0.7118
cogs*vide*gend*inter | 1 | 0.0813897 | 0.0813897 | 0.00 | 0.9727
comput*video_*gender | 1 | 11.2031313 | 11.2031313 | 0.16 | 0.6880
comp*vide*gend*inter | 1 | 5.4375286 | 5.4375286 | 0.08 | 0.7796
cogs*comp*vide*gendi | 1 | 129.2183123 | 129.2183123 | 1.88 | 0.1753
cog*com*vid*gen*inte | 1 | 1.0035786 | 1.0035786 | 0.01 | 0.9043

cogsty*computer_time | 1 | 9.4778222 | 9.4778222 | 0.14 | 0.7118

cogsty*computer_time | 1 | 35.7223533 | 35.7223533 | 0.52 | 0.4739
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compare accuracy across speed differences
The GLM Procedure

Dependent Variable: slow_period_report_error_rate

Class Level Information

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<th>Levels</th>
<th>Values</th>
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Number of Observations Read 112
Number of Observations Used 99

compare accuracy across speed differences

The GLM Procedure

Source | DF | Type I SS | Mean Square | F Value | Pr > F |
-------|----|-----------|-------------|---------|--------|
Model   | 5  | 0.57712015| 0.11542403  | 1.97    | 0.0891 |
Error   | 105| 6.15275826| 0.05859770  |         |        |
Corrected Total | 110 | 6.72987841 | | | |

R-Square 0.085755  Coeff Var 147.6998  Root MSE 0.242070  slow_period_report_error_rate Mean 0.163893

Source | DF | Type III SS | Mean Square | F Value | Pr > F |
-------|----|-------------|-------------|---------|--------|
cogstyle | 1  | 0.16678735  | 0.16678735  | 2.85    | 0.0946 |
computer_time | 1  | 0.00176912  | 0.00176912  | 0.03    | 0.8624 |
video_games | 1  | 0.23960858  | 0.23960858  | 4.09    | 0.0457 |
gender     | 1  | 0.15469538  | 0.15469538  | 2.64    | 0.1072 |
age_cat    | 1  | 0.09035716  | 0.09035716  | 1.54    | 0.2171 |

compare accuracy across speed differences
The GLM Procedure

Dependent Variable: fast_period_report_error_rate

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R-Square  Coeff Var  Root MSE  fast_period_report_error_rate Mean
0.162928   94.17998   0.215567   0.228889

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compare accuracy across speed differences

The GLM Procedure

Class Level Information
Class   Levels  Values
interface  3      1 2 3

Number of Observations Read   112
Number of Observations Used   99

compare accuracy across speed differences

The GLM Procedure

Dependent Variable: fast_period_report_error_rate

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R-Square  Coeff Var  Root MSE  fast_period_report_error_rate  Mean
0.526627  82.22350  0.188200  0.228889
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The GLM Procedure

Class Level Information

Class          Levels Values
interface      3     1 2 3

Number of Observations Read  112
Number of Observations Used   108

compare SA Level 1 accuracy across interfaces

The GLM Procedure

Dependent Variable: SA_ONE_ACCURACY

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R-Square     Coeff Var   Root MSE  SA_ONE_ACCURACY Mean
0.508264     38.35580    16.27405   42.42917

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compare SA Level 1 mean errors across interfaces

The GLM Procedure
Class Level Information
Class   Levels  Values
interface  3  1 2 3

Number of Observations Read  112
Number of Observations Used   108

compare SA Level 1 mean errors across interfaces

The GLM Procedure
Dependent Variable: SA_ONE_MEAN_ERROR

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R-Square Coeff Var Root MSE SA_ONE_MEAN_ERROR Mean
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### GLM Procedure

**Class Level Information**

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**Number of Observations Read**  112  
**Number of Observations Used**  109

### The GLM Procedure

**Dependent Variable: SA_TWO_ACCURACY**

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**R-Square**  0.413089  
**Coeff Var**  45.11392  
**Root MSE**  24.17113  
**SA_TWO_ACCURACY Mean**  53.57798  

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compare report timing across interfaces

The GLM Procedure

Class Level Information
Class Levels Values
interface 3 1 2 3

Number of Observations Read 5339
Number of Observations Used 4941

compare report timing across interfaces

The GLM Procedure

Dependent Variable: report_delay

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R-Square 0.058418  Coeff Var 52.15411  Root MSE 2.949066  report_delay Mean 5.654523

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compare report timing across experiment groups

The GLM Procedure
Class Level Information
Class   Levels  Values
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Number of Observations Read  5339
Number of Observations Used   4941

class xg 6 levels 1 2 3 4 5 6

The GLM Procedure
Dependent Variable: report_delay

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R-Square  Coeff Var  Root MSE  report_delay Mean
0.102498   51.20489   2.895392   5.654523

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<td>DF</td>
<td>Type III SS</td>
<td>Mean Square</td>
<td>F Value</td>
<td>Pr &gt; F</td>
</tr>
<tr>
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<td>0.5893</td>
</tr>
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</table>
The GLM Procedure

Class Level Information

Class          Levels Values
xg            6     1 2 3 4 5 6

Number of Observations Read  5339
Number of Observations Used   4941

compare report timing across experiment groups

The GLM Procedure

Dependent Variable: report_delay

Source                     DF    Type I SS    Mean Square   F Value  Pr > F
Model                       6    2662.30985   443.71831   51.02     <.0001
Error                      4934  42910.96156   8.69699
Corrected Total            4940  45573.27140

R-Square                   0.058418  52.15411  2.949066  5.654523

Source                     DF    Type III SS   Mean Square   F Value  Pr > F
cogstyle                   1    100.303525    100.303525   11.53     0.0007
sitcomp                    1    2119.860476   2119.860476  243.75     <.0001
computer_time             1    191.523818    191.523818   22.02     <.0001
video_games               1    95.479720      95.479720   10.98     0.0009
gender                    1    136.568157    136.568157   15.70     <.0001
age_cat                   1    18.574150      18.574150   2.14     0.1440

Source                     DF    Type III SS   Mean Square   F Value  Pr > F
cogstyle                   1    45.359570     45.359570    5.22     0.0224
sitcomp                    1    2105.693290   2105.693290  242.12     <.0001
computer_time             1    259.593234    259.593234   29.85     <.0001
video_games               1    46.043781     46.043781    5.29     0.0214
gender                    1    136.840592    136.840592   15.73     <.0001
age_cat                   1    18.574150     18.574150    2.14     0.1440
Education

• M.S. in Information Sciences and Technology; the Pennsylvania State University, School of Information Sciences and Technology, completed in 2004. Thesis title: “The Information-Technology-People Abstraction Hierarchy: A Tool for Complex Information Systems Design”
• B.S. in Management Science and Information Systems; the Pennsylvania State University, Smeal College of Business Administration, completed in 2000
• Certification as an Emergency Medical Technician – Paramedic by the Pennsylvania Department of Health; coursework completed through the Altoona Hospital Paramedic Institute in 1990; other emergency services certifications, including instructorships, predate this.

Publications


Teaching

• MIS-442: “Object-Oriented Business Systems” – Fall 2009 & Spring 2010, The Pennsylvania State University’s Smeal College of Business, Department of Supply Chain & Information Systems
• KINES-403 (formerly HLED-403): “Emergency Medical Technology”, lecturer and clinical skills instructor on various topics in the curriculum; 1989-1991, 1998; The Pennsylvania State University’s Office of Emergency Medical Services

Presentations / Seminars

• Invited speaker to the 2003 and 2004 Penn State University's Web Developers Conferences (see www.psu.edu/webconference). Presentation topics centered on web-database security issues.
• Guest Lecturer for the Pennsylvania Governor’s School for Information Technology during the 2003, 2004, and 2005 summer sessions.