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The Effects Of Secondary Task Demandon The Assessment Of Threat

Harriss Ganey
University of Central Florida

THE EFFECTS OF SECONDARY TASK DEMAND ON THE ASSESSMENT OF THREAT

by

H.C. NEIL GANEY
B.S. University of Central Florida, 1999
B.S. University of Central Florida, 2001
M.S. University of Central Florida, 2004

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ABSTRACT

Threat perception is an important issue in today's world. As the line between hostile and non-hostile entities is blurred, it becomes more important for individuals to clearly distinguish between those who would present danger and those who would not. This series of experiments tested whether observers engaged in a dual-task paradigm perceived a greater amount of threat from target stimuli than they did when they were engaged in the threat task alone.

The first experiment revealed that observers rated targets as more threatening when they were engaged in the additional task than when they only rated the targets themselves. Response time to the targets was also slower when a secondary task was present. This difference was more pronounced when the secondary task was presented via the auditory channel. Participants also rated overall workload higher when performing a secondary task, with the highest ratings being associated with the dual-task auditory condition.

In the second experiment, the design crossed sensory modality with the presence or non-presence of threat. Inter-stimulus interval was also manipulated. The presence of threat was associated with faster response times, though when both tasks had threat components, response time was not the fastest.

Additionally, when images came first in the stimulus pairs, observers were slower to respond to the first stimulus than when the sounds were presented first.

Results supported the conclusion that additional task loading can affect the perception of threat. The modality of the additional task seems to also play a role in threat assessment performance. Results also led to the conclusion that threat-related visual stimuli are more challenging to process than threat-related auditory stimuli. Future research can now investigate how different types of tasks affect the threat perception task. Implications for better training of soldiers and for the design of automated systems are presented.

This is for my wife, Katie, who has stood with me through the creation of this manuscript; my advisor, Peter Hancock, who has stood by me through my graduate school career; and my family who have stood with me since the beginning.

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CHAPTER 1 - INTRODUCTION

The United States is increasingly becoming more involved in conflicts around the world with enemies that are not clearly defined (Scales, 2006). This ambiguity makes the decision-making processes difficult for military personnel of the various branches within our military due to the increasing threat that is posed by people with whom they come into contact.

For example, many of the forces that the United States have engaged recently have not been in traditional or common uniforms. Like the colonial forces that thwarted the British in our own Revolutionary War; the guerilla tactics employed by current enemies make it more challenging for U.S. forces to be successful in a conflict.

Logic would dictate that in Military Operations in Urban Terrain (MOUT) the importance of the decisions made by the soldier, as well as the pressure to make the right decision, becomes even greater than in conventional warfare due to the ambiguity and time pressure inherent in the role. In MOUT, soldiers must not only discriminate friend from foe, but they must also determine those who are non-foes. Combatants have the ability to hide by just appearing to be a resident in a house that is being patrolled, only to attack the soldiers as they walk away. Thus, the discrimination task faced by the soldier can change from a binary yes-no task to a more fuzzy classification (Galantino, 2003). In these cases, it is less obvious to the soldier who their friends and enemies are because of the non-foe category, which can blur the line between; overlapping the friend and foe categories.

According to Levinson and Edwards (1997), in the year of 1987 on the 17th of March, at 8:00 PM EST an F-1 Mirage fighter jet took off from Iraq's Shaibah military airport and headed south toward the Persian Gulf, flying along the Saudi Arabian coast. Aboard the USS Stark, radar operators picked up the Mirage when it was about 200-miles away. The Captain was not alarmed because he knew it was fairly common for Iraqi and Iranian warplanes to fly over the Persian Gulf. The USS Stark requested identification from the jet twice without response. At 10:10 PM EST, the Iraqi pilot launched two Exocet missiles. For reasons unknown, the sea-skimming missiles were not detected by the USS Stark's sophisticated monitoring equipment. Therefore, the commander of the USS Stark, made the decision ***not*** to engage an inbound aircraft that was regarded as a non-threat to the ship. As a result of this decision made from inaccurate information, 27 U.S. Naval personnel lost their lives.

According to Collyer and Malecki (1998) and Fogarty (1988), in the Combat Information Center of the USS Vincennes, Captain Will Rogers III had just seven minutes to decide whether or not to fire at the Iranian aircraft coming straight for him. Half-an-hour earlier the USS Vincennes and the USS Elmer Montgomery had clashed with Iranian gunboats. The Captain became more convinced that the aircraft, which had taken off from a joint military-civilian field, was an Iranian F-14. The aircraft was acting suspiciously; it did not respond to several warnings to identify itself, and transmissions from the aircraft were detected on a military frequency. When the aircraft was nine-miles away, Captain Rogers ordered the firing of two SM-2 surface-to-air missiles. At least one missile hit the target, which turned out to be Iran Air Flight 655, a civilian airliner. The commander of the USS Vincennes made the decision to engage an inbound aircraft believing it was a threat to his ship, and all 290 personnel and passengers aboard the commercial airliner were killed as a result.

While this condition has been recognized for the past decade in the command-and-control venue (Fogarty, 1988), very little attention has been paid in the literature to the relationship between the dismounted soldier and this issue. The following observations describe several events that bring the need for research into military decision making under stressful conditions to the fore.

Just recently, a highly publicized incident occurred along the Baghdad International Airport road and resulted in the wounding of the Italian journalist Giuliana Sgrena and the death of her rescuer, Nicola Calipari. While the accounts of what happened vary, the soldiers clearly opened fire on a vehicle containing non-foes. These soldiers, many of them teenagers, had to establish and maintain a checkpoint along one of the most dangerous stretches of road in the world. There had been a large number of military casualties due to suicide bombers. It was night time and these soldiers had not been in Iraq long. The soldiers had perhaps two or three seconds to make a life or death decision. Is this a foe, driving a car loaded with hundreds of pounds of explosives ready to explode, or is it a non-foe, possibly having taken a wrong turn?

While all of the findings have not been made public, it is clear from the information provided that there was a great deal of uncertainty involved in the situation. It is now suspected that the car's driver was multitasking, including being involved in a cellular phone conversation. This, combined with the vehicle's speed, which was estimated at around 50 miles-per-hour, likely led to the fatal end of the interaction.

According to Scales (2005), "On thousands of occasions in places like the graveyards of Najaf and the back alleys of Fallujah, lower-ranking soldiers and Marines are responsible for saving lives or taking them. If they hesitate too long to open fire, they die. If they open fire too precipitously, an innocent dies."

Several studies examined threat assessment, as performed by soldiers in the field, and included additional demands on their attentional resources posed by a secondary task. The purpose of the first study was to determine whether secondary tasks had any effect on the performance of threat assessment tasks and if there were effects for the modality of the secondary task presentation. The purpose of the second study was to determine whether the modality of the threat stimulus affected the task performance differentially and to find out how two threat related tasks would affect performance and workload. This line of research is important because individual soldiers are being called upon to perform more roles simultaneously, while sustaining positive levels of performance. If it is found that a soldier's judgments of threat do vary as their workload changes, then practitioners can step in to make interventions. Some potential interventions include training, new personnel selection criteria, and the development of technology that could assist the soldier in either the threat assessment task or any additional tasks the soldier might be facing. It must first be determined, however, what a soldier is able to do without degrading any performance capability. The outcome of this research can be used to design new training protocols, as well as aid in the design of assistive automation systems.

Organization of the Dissertation

This Dissertation proposes that secondary tasks interfere with the performance of threat assessment tasks. This interference may manifest itself either through changes in response accuracy, response time, or both. In the case of response accuracy, it is anticipated that the change will be a criterion shift, rather than a change in sensitivity. More specifically, the criterion shift should be towards a more liberal bias. This effect will be described more fully in a later section.

This first chapter serves to establish and discuss the need for the research and to give a frame to the problem. The second chapter reviews the relevant research and how the current research program emerges from the present state of understanding. The third and fourth chapters discuss the method of and results of two experiments conducted to examine how secondary tasks affect judgments of threat.

The first experiment focused on the secondary task itself, taking a commonly used laboratory task and manipulating the perceptual modality of the stimuli. The goal of this experiment was to discover if secondary tasks affect threat assessments and, if so, does the perceptual modality of the secondary task play a role in the performance decrement caused. The presentation modality of the secondary task was manipulated and include both visual and auditory stimuli.

The second experiment manipulated both modality and threat level of each task. The goal was to determine whether changes in response criteria towards threat-related stimuli was modality specific. Additionally, the inter-stimulus interval was manipulated, using a psychological refractory period paradigm (Smith, 1967; Telford, 1931), to determine whether threatening stimuli are processed automatically or if they require deeper processing. The psychological refractory period, which will be discussed further in the next chapter, involves determining how much time is required for an observer to process a stimulus. This is done by manipulating the length of time between the first stimulus and the presentation of a second stimulus. The smallest period of time between the two stimuli where the participant is able to respond to the second stimulus represents the psychological refractory period.

Chapter Summary

Threat assessment is a very real problem for the men and women of the U.S. Armed Forces. The TADMUS research acknowledged this problem in the early 1990's. The focus of the program was on command and control personnel. Here, the focus is on the individual soldier. In the case of the command center personnel, the threat is generally more distal in nature and the operator can feel removed from the situation, with his or her task sometimes seeming like a video game. The proposed set of studies look at threat assessment, as performed by soldiers in the field, and include additional demands on their attentional resources as posed by a secondary task. This is much more immediate than the command and control task and much more appropriate to current, real-world issues in contemporary conflicts.

CHAPTER TWO: REVIEW OF THE LITERATURE

Information Processing

A foundational topic in the study of behavior is the investigation of how humans perceive and process what is going on around them. The first definition necessary for a discussion about this phenomenon is that of information. Information can be classified as representations that a person makes of their environment derived from both the environment itself and the person's own internal functioning. Information processing then refers to those internal functions which govern what inputs the human uses in their assessment of their environment.

Many theories and models have been developed in an attempt to explain the flow of information (e.g., Baddeley and Hitch, 1974; Broadbent, 1958; Kahneman, 1973). The common theme in each of these theories is that humans have limited mental capacities. Thus, there is some capacity to the number of items that a person can attended to at any one time (Miller, 1956). A person has to be selective in determining what stimuli he or she should attend to and in varying the amount of mental effort designated for the task (Kahneman, 1973). In general, the person's current motivations and intentions determine how much of his or her voluntary effort is exerted while focusing on particular activities. For soldiers, a great deal of motivation is focused towards threats, since they represent risks to themselves and their fellow soldiers. Threatening stimuli should garner priority when the soldier is selecting which stilumi he should attend to.

When performing mental tasks, different mental operations (e.g. perceiving, rehearsing, and responding) must be carried out, and performance of each requires some degree of the individual’s limited processing resources. Since resources are limited, time-sharing may be required. Divided attention occurs when two or more tasks must be performed simultaneously and attention is required for the performance of all tasks. Irrelevant stimuli are filtered and disregarded while attention is divided to accommodate parallel processing of pertinent items (Kahneman and Treisman, 1984). In the threat assessment task that soldiers are engaged in, pertinent stimuli would definitely include the people around them in the environment. The set of stimuli that would represent irrelevant stimuli is a little less clear. Anything in the environment could be abnormal and lead to risk. So, it is difficult for the soldier to clearly determine what he should pay attention to as they make their patrol.

Some operations may require resources that are different from others. As a consequence, there is less competition between these processes for their enabling resources, and time-sharing between them may be more successful (Wickens, 1984).

Component Theories of Information Processing

The filter proposed by Broadbent (1958) blocks some of the information passing from perception to processing and explained how a person could be inundated with large amounts of information and still be able to focus on a specific portion of that information. Eysenck (1982) referred to this filtering between perception and processing as Stage 1 selection. If this were to occur to the soldier on patrol, the soldier would not perceive visual information that did not relate to his mission, thus the kind of trees lining the street might not be noticed.

Treisman (1960, 1964) found that people could attend to auditory information being presented into both ears, even when characteristics of the sounds, like tone and volume, were kept the same. If a filter existed between the stages of perception and processing, this could not have occurred. Instead, she found that subjects were able to attend to the content of the information, regardless of the ear which it was presented to. This led researchers to believe that the filtering occurred after processing, which is known as Stage 2 selection (Eysenck, 1982). Looking back to our soldier, he might notice the children playing in the empty lot to his right, but would not consider it further in favor of looking out for potential threats.

As an extension to Treisman's findings, Norman (1968) proposed a modification to account for the pertinence of the input to the human. In this model, both sensory activation and the content of the information to the person play a role in the filtering process. A person's name, for instance, traditionally has a significant amount of pertinence to himself (Moray, 1959). When an input is both important to the person and is sufficiently salient, the person will attend to it.

Resource Theories of Information Processing

Most resource models are presented with attentional capacity being likened to a pool or reservoir (Knowles, 1963). As demands from the primary task increases, the amount of resources available for a concurrent secondary task decrease. In capacity models, resources can be allocated to more than one task at a time. This model can therefore be used to explain how a soldier could be able to both monitor a street that they are patrolling and hear information from their commander on their earpiece at the same time. This is in contradiction to structural models, which only allow for a single task to be performed at any given time.

Moray (1967) likened the human to a computer that can dedicate its processing resources to any task, up to its capacity. So, rather than having a regulatory structure in the process, restrictions in performance only occur when the available resources are exhausted.

Within the scope of most resource theories is the premise that all tasks and mental activities share the same resources. Resources are expended either by making the aspects of the task more difficult or by imposing additional responsibilities. Through increases in physiological arousal arising from the increased task demand, more resources are made available. These additional resources may still not be enough to ensure proper task performance, so decreased task performance coincides with increased resource utilization.

The most favorable situation with respect to resource models is during single-task performance, when all resources are invested in the task. The inclusion of a concurrent task then diverts resources away from the original task and may lead to performance decrements. The effect that the additional task has on the remaining amount of resources depends on the characteristics of each task being performed. If a task is data-limited, then performance is not increased through additional resource usage, but rather through the quality of the data necessary to perform the task. This is most often seen in cases where performance can be sustained with very little resource use, such as highly practiced tasks (Wickens, 1991).

Alternatively, if performance is altered when the amount of resources devoted to the task changes, the task is resource-limited. This and similar theories assume that individuals have the ability to allocate the available resources to the tasks they are engaged in (Gopher, 1982; Gopher & Navon, 1980; Wickens, Sandry, & Vidulich, 1983).

Kahneman's capacity model (1973) extended traditional single-resource theories by suggesting that there is a single undifferentiated pool of resources. His model serves to explain cognitive processes during multi-task situations and allocation of resources to mental activity. This model assumes that there is a basic limit on any individual's capacity to perform tasks that require mental effort. In addition, the model illustrates how individuals can allocate this capacity among concurrent activities. Activities fail or performance degrades because either the allocation policy channeled available capacity to other activities or the demands of the tasks are beyond the capacity of the individual.

Even when resource demand is low, performance can still be disrupted by external circumstances. An example of this would be a reflexive response to an unexpected noise. An unforeseen rifle burst would constitute such a stimulus. Individuals respond to such stimuli at an instinctual level, reducing attention to other tasks. Allocation of attention is also impacted by momentary intentions, which can manifest as personal objectives requiring focused attention or as distracting thoughts. These internal diversions may influence attention available for other tasks. The person's evaluation of the demands that are imposed on himself controls the supply of capacity, as determined by the tasks selected by the allocation strategy.

Dual-task Performance

It is not possible to fully prepare for two tasks that are both separate and novel at the same time. In fact, when people are asked to execute two unrelated tasks simultaneously, performance on the tasks is worse than when the respective tasks are performed in isolation (see Driskell, Mullen, Johnson, Hughes, & Batchelor, 1992).

Before any further discussion, a definition is needed for the term "task." A task is any set of both input and output on the part of the human. This simplistic explanation covers a wide range of activities. At the simple end of this range is the person seeing a square appear on a computer screen and pressing a button to acknowledge seeing it. Near the complex end of this range is the human flying an airplane, where a multitude of sub-tasks are involved in keeping the plane aloft, using the various instruments available to him.

In a typical dual-task paradigm, observers are asked to recognize two separate stimuli and to make separate responses to each of the stimuli. If the tasks involve responding to two visual stimuli that are separated by a large visual angle, performance may suffer because both stimuli cannot be fixated on at the same time. Similarly, if the tasks involve responding to two different stimuli using the same motor response, dual-task performance may suffer because the participant can initiate only one response at a time with the same appendage.

To avoid these limitations, dual-task stimuli sets are often presented in different sensory modalities and the responses are made using different response types. For example, a single digit number may be flashed on the computer screen followed by a sound that may be either high or low in pitch. The participant's task would be to say "even" or "odd" to indicate whether the digit was either even or odd and then to press one of two response keys to indicate whether the sound was high or low in pitch.

A very robust finding in dual-task experiments is that the response time to the second stimulus (the sound, in this example) is slower than when the stimulus is presented alone (Lien & Proctor, 2002; Pashler & Johnson, 1998). Furthermore, the relationship between the response time and the period of time between the two stimuli in inverse: that is, as the time between the digit and the sound being presented is decreased, the time required to make the response to the sound is increased. This period of time between the two stimuli is referred to as stimulus onset asynchrony (SOA: Ferreira & Pashler, 2002; McCann, Remington, & Van Selst, 2000; Pashler & Johnston, 1989; Pashler, Johnston, & Ruthruff, 2001). This could mean that, even though the soldier sees a person ahead of him drawing a weapon, his response time would be slowed because he had been paying attention to his commander’s orders coming through his headset.

This slowing of the response to the second stimulus has been called the psychological refractory period (PRP) effect (Bertelson, 1967; Smith, 1967; Telford, 1931). As the name suggests, early theorists thought that the first stimulus had a physiological inhibitory effect on the processing of the second, stemming from the refractory properties of neurons. Although this explanation has long been discredited, the name has been retained.

There are some special cases that exist in dual-task paradigm performance. In cases where the two stimuli are related, observers respond more quickly than in cases where they are only presented with one of the stimuli (for a review of these findings, see Townsend & Nozawa, 1995). This is known as the redundant signals effect. In these situations, it is believed that the non-visual stimulus serves as a cue for the observer and that facilitates response time (Sanders & Wertheim, 1973). Visual stimuli seem to be ineffective for cueing, however (Nissen, 1974), which may represent the difficulty that observers have in switching their attention away from visual stimuli.

Also, certain sensory modalities produce very different results. Vision is the primary sensory pathway for most humans, so information that is seen is weighted differently than information from other sensory channels.

Visual Dominance

Humans have a tendency to give more attention to visually-perceived information. Researchers have called this “visual dominance” (Howard & Templeton, 1966; Pick, Warren, & Hay, 1969; Rock & Victor, 1964).

The first research identifying the capture of visual attention in dual task conditions is attributed to Gibson (1933). In this study, participants were asked to wear eyepieces that made straight lines appear curved. When the participant was asked to move their hand along the straight edge of a surface, they reported that the edge was curved, even though what was felt was straight.

Visual dominance is a phenomena that is also seen in memory research. Klein and Posner (1974) asked participants to reproduce a pattern of movement that they either saw, felt, or both saw and felt. In the cases when participants both saw and felt the pattern, half of the times they were told to focus on one of the pattern modalities. It was found that even in the scenarios where they were told to only focus on the kinesthetic stimuli, they could not ignore the visual stimuli.

Visual information also tends to dominate auditory information, as well (Pick, Warren, & Hay, 1969). In a series of experiments, Colavita (1974) found that people tend to focus on visual information, even when visual and auditory information are presented concurrently. In the studies, participants were presented with visual stimuli and auditory stimuli, which they were asked to respond to with separate key presses. On 5 of the 30 trials, a visual and auditory stimuli were presented simultaneously. 10 participants were used in the study, and in 49 of the 50 trials where the stimuli were presented simultaneously, participants did not respond to the auditory stimulus. In this case, the stimuli were not connected.

Signal detection

Many methods have been employed over the years to analyze the way humans process and make decisions based on information; among them is signal detection theory (Green & Swets, 1966; Macmillan & Creelman, 1991). Information processing is an important component of signal detection theory. While it does not rely on a specific model, signal detection theory hinges on how the observer perceives the world and, based on those perceptions, the response (or non-response) employed. At the heart of signal detection theory is the assumption that all stimuli that are perceived by a human operator represent either what the operator is searching for or not. In the case of a threat detection task, these would be represented by people who a threats and those who are not. These two types of stimuli are known as signal and noise, respectively. These two elements are then observed in the context of whether the operator responded to the stimulus or not, whether the soldier engaged the person or let them pass. This produces a 2 x 2 matrix into which all combinations of stimulus and response can be placed.

The four categories are known as hit, miss, false alarm, and correct rejection. A hit is a case where a signal did occur and the operator responded to it. This would involve the person being a threat and soldier determining that the person was a threat. A miss involves a signal occurring, but no corresponding response. In this case, the threatening person would not be responded to by the soldier. A false alarm happens when the operator responds to a stimulus that is not a signal, like the soldier responding to a person who does not pose a threat. A correct rejection involves the operator not responding to a non-signal stimulus, or when the soldier lets a non-threatening person pass without response.

Shifts can occur in an operator's performance over time. There are two basic types of shifts, one of which is an aspect of the stimuli and the other is an aspect of the operator. A shift in sensitivity, known as d', involves being able to distinguish more clearly the difference between signal and noise (Macmillan & Creelman, 1991). So, it would be easier for the soldier to distinguish between the threat and the non-threat people. A criterion shift, known as β, is where the operator changes their overall proportion of responses (Macmillan & Creelman, 1990). Operators who do not respond often are considered conservative, while those who respond often are regarded as liberal. This would be represented by a soldier who never instigated a response against a person or one who commonly responded to people as threats, whether they were or not.

Mental Workload

Workload is a factor that has often been linked to detection performance. In cases where the operator reports feeling greater amounts of workload, a trend toward worse performance on the detection task is usually found.

There are many methods available to measure workload (Gawron, 2000). These methods fall primarily into four categories: primary task measures, secondary task measures, physiological measures, and subjective measures (Jerome, Ganey, Mouloua, & Hancock, 2001; O'Donnell & Eggemeier, 1986). Primary task measures of mental workload concentrate on changes in the performance of the task identified as primary in a task set. Secondary task measures look at the same factors in any additional tasks in a task set. Physiological measures of mental workload collect physiological information from the participant during the course of the experiment and look for patterns of changes in the information coinciding with task load variations (De Waard, 1996). Subjective indices of mental workload involve the participant responding to questionnaires and scales that ask for their perceptions regarding their performance on the task and the level of difficulty they experienced (Hart & Staveland, 1988; Reid & Nygren, 1988).

Primary task measures concern the level of difficulty in the task. Researchers who are concerned with primary task performance effects would manipulate the task load imposed by the primary task. When paired with another task, the manipulation of task difficulty may not occur. All primary task measures are in some way based on either response accuracy or response time (De Waard, 1996).

Secondary task measures are derived from performance differences that occur in a multi-task paradigm. In these cases, the participants are customarily told to work on all of the tasks that they are given and to pay more attention to one task, which is the primary task, over the other. The mental workload is them reflected in performance decrements in the secondary task, if primary task performance remains constant.

Subjective measures are based upon the participants' responses to questions either during or after the task session. These questions generally involve the participant assessing the level of effort that they put towards the task set. The strength of these measures is that no one knows what the participant is experiencing better than the participant themselves (Muckler & Seven, 1992).

Threat

There are many accounts of soldiers missing their target in combat who were otherwise very accurate shooters (Baddeley, 1972). According to Walker and Burkhardt (1965), there is evidence from the battle of Gettysburg during the American Civil War that over 200 rifles had been loaded five times or more without being fired. Why would that happen, especially if those soldiers had trained on the rifle range? The answer may be that the facets of the battlefield experience may affect their performance. These facets could therefore be stimulus-based and/or environment-based.

Environment-based Threat

Continuing with the shooting skills example, one reason for the performance decrement could be that those soldiers had acquired their marksmanship skills while in a relatively safe environment, without the accompanying stress that is present in battle. Researchers have investigated the role of environmental stress and workload on performance extensively.

In his article, Baddeley (1972) discusses the role of threat unrelated to the task on performance. His survey of the literature presents a compelling argument. Initially, he and his colleagues (Baddeley, 1966; Baddeley & Fleming, 1967) suspected that the pressure caused by the depth that divers were at caused the performance decrements. When they compared performance between divers and participants in a hyperbaric chamber set to the same pressure, they found that the divers still showed a greater decrement in performance than the pressure chamber participants. It therefore seemed to be due to some risk or threat associated with being underwater (Baddeley, 1967, 1972).

Hancock and Milner (1982) also found similar results. In their studies, they tested participants on both a psychomotor task and a simple mathematical task. While there was no difference between the mean correct for the addition task, participants made more errors at 15.2 meters than at 4.6 meters or on the surface. In the psychomotor task, the mean movement times were significantly higher when participants were under water when performing the task than when they performed it on the surface. While the psychomotor data can be explained by the slowing of motion that occurs underwater, the mental math findings can only be explained by some threat explanation since the more shallow depth did not produce more errors than the out of the water condition.

Hammerton and Tickner (1968) tested military parachutists in a manual control task at least a day before a jump, immediately before going into the air for their jump, and just after completing the jump. The soldiers were divided by experience. They found that soldiers with less jump experience showed worse performance just prior to their jump. This decrement was attenuated with more prior jump experience, with the regular paratroopers showing almost no change in performance. It would seem, then, that greater experience with a potentially stressful task can lead to mitigation of the more deleterious effects of the stress associated with the task.

Task-based Threat

The task that a person is performing can itself be threatening. Bomb disposal technicians know that an incorrect decision can result in harm to not only themselves, but other people, too. In the research performed on explosive ordnance disposal personnel (Cox, Hallam, O'Connor, & Rachman, 1983; Hogan & Hogan, 1989; O'Connor, Hallam, & Rachman, 1985; Rachman, 1983), these variations were considered in terms of fearlessness or courage. This would lead to two possible explanations. Either the operator does not perceive the same amount of threat in the bomb situation as their counterparts or they are able to employ a more task-focused coping style (Lazarus & Folkman, 1984). This would mean that the operator sees the bomb as a threat, but understands that it is just part of the task and does not let that take up too much of his thinking. Likewise, soldiers understand that if they shoot at someone that should not have been shot at, there may be grave repercussions. The soldier cannot let this cloud their mind, however. This could therefore be a differentiation between more effective and less effective soldiers.

CHAPTER THREE: EXPERIMENT 1

Program of Research

The purpose of the proposed set of studies is to investigate the effect of certain types of secondary tasks on threat assessment in simulated military situations. At present, not much is known about threat assessment, perhaps because soldiers have only just recently begun to have to change their judgment systems from binary, friend/foe discriminations to more fuzzy, friend/foe/non-foe discrimination (Battistelli et al., 2000; Galantino, 2003). For the proposed study, threat assessment will be conceptually defined as the level of danger or risk, to the decision maker's self or the entities within the decision maker's area of responsibility, which is assigned by that decision maker to a person or an object.

As a soldier assesses the likelihood of threat in a situation, then that soldier might change the assessment of the likelihood of threat based on secondary task factors. According to Tolcott (1992), situational assessment and action selection are the two primary components of military decision making. Changes in the level of perceived threat, therefore, might affect the actions taken by the soldier in response, causing some potentially deadly consequences. If it is discovered that secondary task load affects assessed threat, investigation could then be made into methods for mitigating this effect, through training, personnel selection, or assistive system design.

Experimental Method: Experiment 1

Experimental Independent Variables

In the first study, the modality of secondary task was manipulated. Secondary task demand therefore came from a task that was either auditory or visual.

Participants

Participants were 40 cadets from the United States Military Academy, both male and female, ranging in age from 18 to 22. This number was selected based on the manipulations required for the design to account for moderate levels of power (Cohen, 1992). They were drawn from first-year cadets enrolled in the Psychology for Leaders course. Participants received extra credit in the course for their participation.

Tasks

Participants were given a primary task of threat assessment. The threat assessment task involved participants viewing pictures of scenes based on the Threat Assessment Test Exercise (TATE; Koltko-Rivera et al., 2005). Examples of these images are shown in Figures 3.1 through 3.4. The participants then gave a threat rating, ranging from 0 (low threat) to 9 (high threat). These images were presented on a 17-inch computer screen for 1 seconds each, with a 9-second inter-stimulus interval. Responses were via button-press and were recorded by the computer.

Additionally, participants were given a secondary task, where the stimulus was presented in either a visual or auditory manner. The secondary mental tasks were based on the “two-back” task (Braver et al., 1997; Rosvold et al., 1956), with one stimuli set being presented in a visual manner and the other set presented in an auditory manner. The “two-back” task has been used quite often in cognitive psychology research as a cognitive loading task (e.g., Gray, 2001; Griffiths, Campbell, & Robinson, 1998; Hildebrandt, Moller, Bussman, & Basar-Eroglu, 2001; Kim, Kim, Lee, Lee, et al., 2002). It requires the participant to recall the character, in this case single digit numbers, that was presented two prior to the target character, which for this task was the number 2. It has been used for visual, auditory, and haptic stimuli. This task was chosen based on its ease of manipulability and its acceptability as both a visual task and an auditory task. The visual stimuli were presented on a computer screen, while the auditory stimuli were presented via headphones at a level that is adjusted for listener comfort. Participants engaged in the cognitive task for 25 minutes. The response to the secondary task, regardless of modality, was verbal and the responses were logged by the experimenter.

Dependent variables

Participants judged each image they saw using a ten level scale, with 0 being the lowest threat and 9 being the highest threat. This was based on an expansion of a threat classification system that is used in law enforcement contexts. The numbers were specifically selected both to expand upon the options in the law enforcement scale continuum, and so that threat responses could be made with a single keystroke.

An analysis on participants' performance on the "two-back" mental tasks was done, as well. The participant's errors in recalling the digit and response times for the mental secondary tasks were recorded. Participants did not have knowledge of results, and correct and incorrect responses were logged.

Research design

This experiment used a within-subjects design with 2 types of secondary task modality: visual and auditory. The order of presentation for the task modality manipulation and the order of stimuli in both the primary and secondary tasks were balanced to prevent any order effects.

Hypotheses

- As the resources that can be allocated to task completion are taken for the successful completion of additional tasks, the threat that is perceived by the observer, with regard to the images, will increase. This is because the participant should adopt a more liberal criterion for response, since there are no repercussions for false alarms.
- Participants involved in the dual-task visual condition will have higher threat ratings than participants in the auditory dual-task condition. This is because the resources available for the tasks will be used up more quickly (Wickens, 1984) and, to compensate, the participant will err on the side of caution with his or her ratings.
- Participants will rate workload higher when they have participated in the dual task conditions, as compared to when they performed the single task baseline condition.

Procedure

The first session began with a review and signature of the informed consent. Participants then performed single task examples of each of the tasks to be performed for baseline assessment. After baseline, the NASA-TLX was administered. The participants then began one of the two dual task condition tasks, followed by the NASA-TLX. The second session involved the participants completing the other dual task condition, followed by the NASA-TLX and the after participation informed consent, as required by the United States Military Academy Human Subjects Review Board. The order of the sessions was counterbalanced across participants.

Results: Experiment 1

A one-way within subjects multivariate analysis of variance was performed on five dependent variables: response to primary task, response time for primary task, response to secondary task, response time to secondary task, and subjective workload. The independent variable was presentation modality of the secondary task stimuli (visual and auditory). Tukey's Least Significant Difference (LSD) was used for post-hoc testing, unless otherwise stated.

Results from Task Performance

For participant response, a main effect was found for second task, $F(2,78) = 3267.725$, $p < .0005$, $\eta^2 = .988$. Post-hoc analysis revealed that the mean threat response was lower at baseline (M =

4.019, SE = 0.178) that in either the visual (M = 4.841, SE = 0.167, $p < .0005$) or auditory (M = 4.85, SE = 0.163, $p < .0005$) secondary task conditions, which were not significantly different from one another, as shown in Figure 3.1.

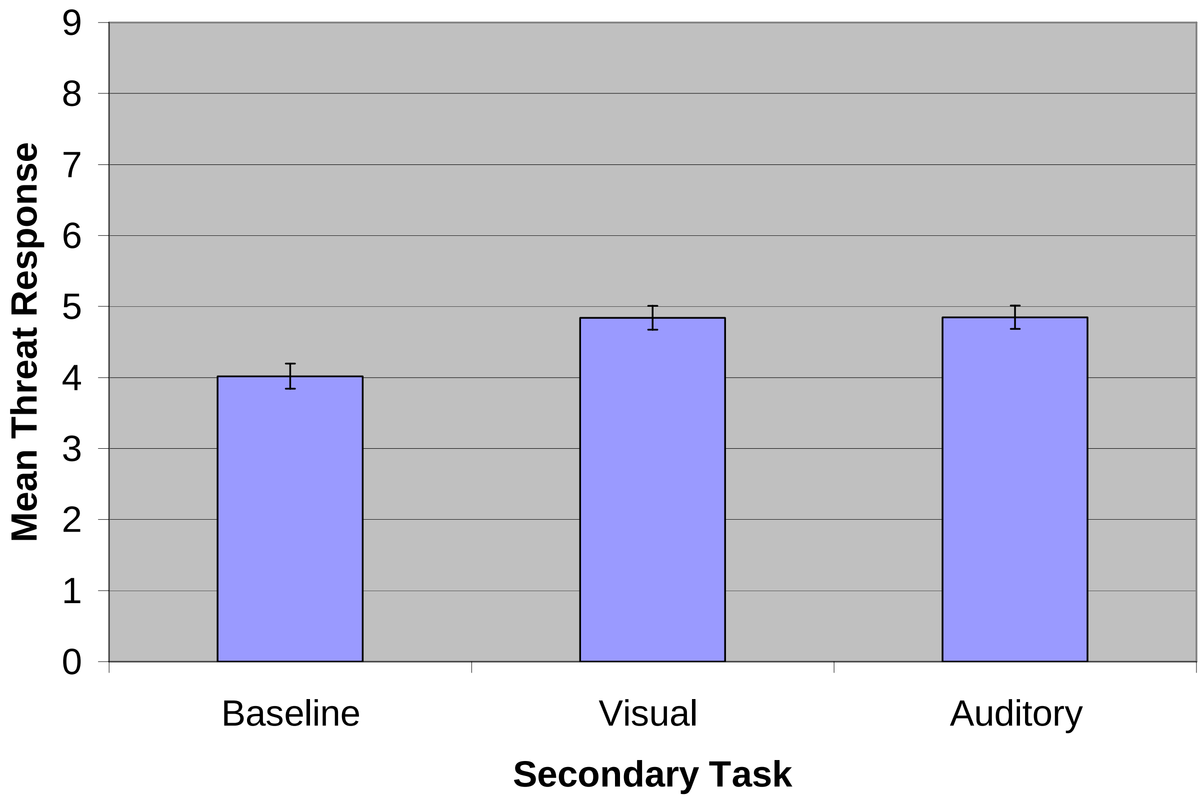


Figure 1 - The effect of secondary task on mean threat response

For response time, a main effect was found for second task, $F(2,78) = 347.444$, $p < .0005$, $\eta^2 = .899$. Post hoc analysis revealed that response time was significantly faster when there was no secondary task (M = 1294.527, SE = 4.819) than when they had a visual secondary task (M = 1323.578, SE = 4.746, $p < .0005$). Both the no secondary task and visual secondary task conditions showed significantly lower average response times than the auditory secondary task condition (M = 1426.217, SE = 3.879, $p < .0005$), as shown in Figure 3.2.

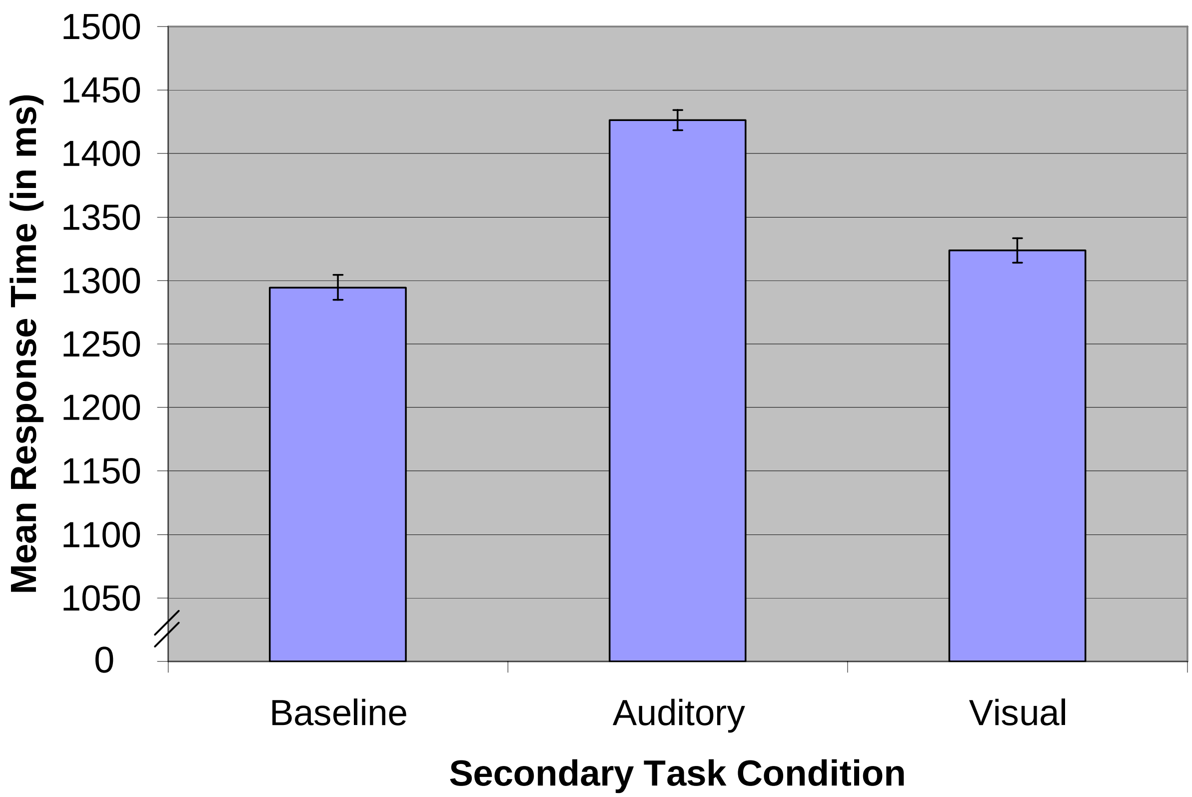


Figure 2 - The effect of secondary task on mean response time in the primary task

A main effect was found for secondary task on response performance in the secondary tasks, $F(3,117) = 19.271$, $p < .0005$, $\eta^2 = .331$. Post-hoc analysis revealed that the dual task auditory condition ($M = 0.875$, $SE = .135$) produced significantly more errors than did either the base line conditions (auditory: $M = 0.175$, $SE = .061$, $p < .0005$; visual: $M = 0.15$, $SE = .057$, $p < .0005$) or the dual task visual condition ($M = 0.225$, $SE = .067$, $p < .0005$) as shown in Figure 3.3.

A main effect was found for secondary task on response time in the secondary tasks, $F(3,117) = 265.587$, $p < .0005$, $\eta^2 = .872$. Post-hoc analysis revealed that the dual task auditory condition ($M = 1544.278$, $SE = 17.808$) showed significantly slower response times than did either the base line conditions (auditory: $M = 1219.009$, $SE = 6.998$, $p < .0005$; visual: $M = 1201.923$, $SE = 12.936$, $p < .0005$) or the dual task visual condition ($M = 1219.004$, $SE = 6.683$, $p < .0005$) as shown in Figure 3.4.

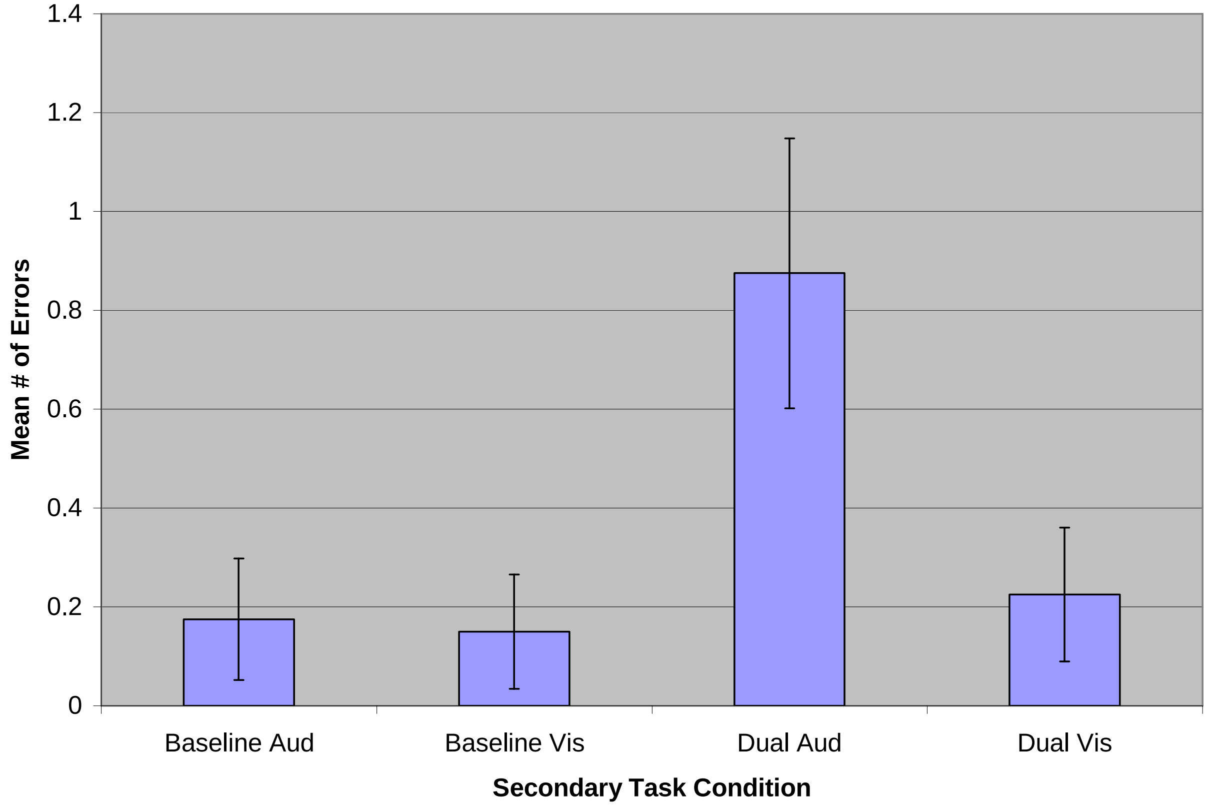


Figure 3 - Mean number of errors committed in the secondary task as a function of secondary task condition

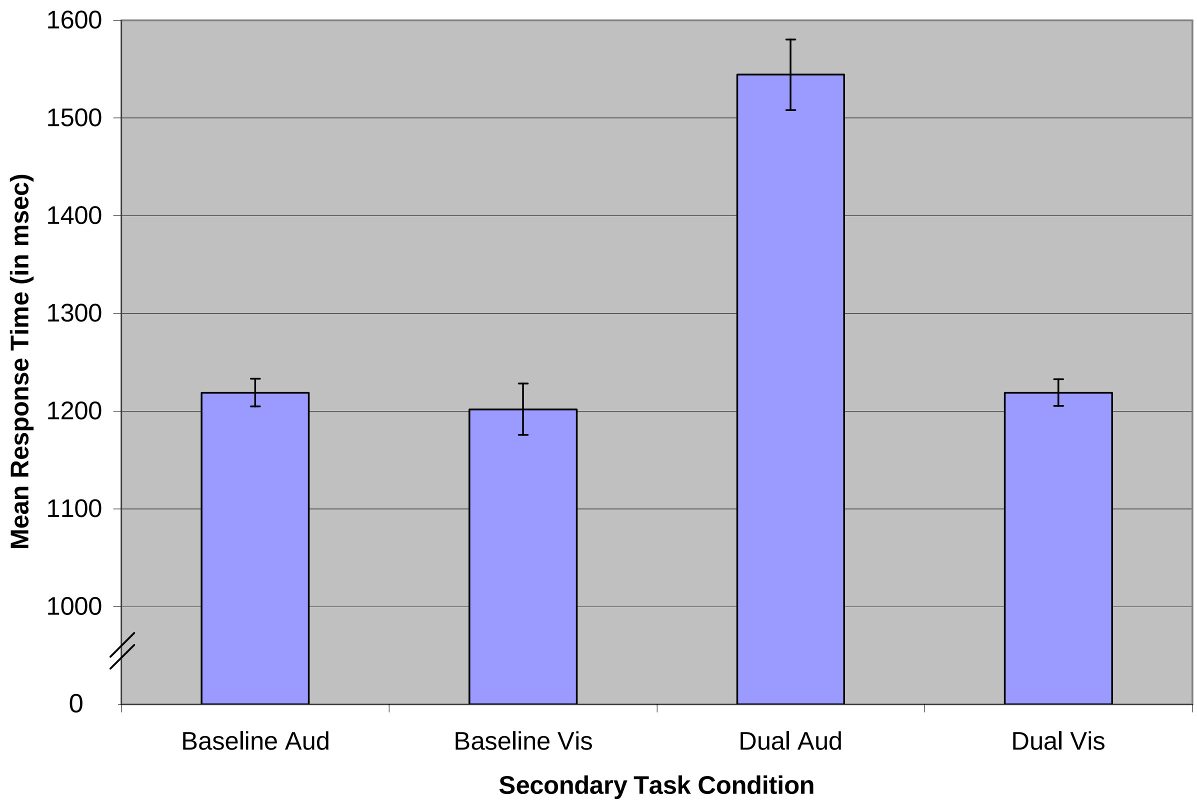


Figure 4 - Mean response time on the secondary task as a function of secondary task condition

Results from Subjective Workload

A significant main effect was also found for secondary task condition on average workload rating given on the NASA-TLX, $F(2, 117) = 31.315$, $p < .0005$, $\eta^2 = .349$. Post hoc analysis revealed that all of the conditions were significantly different (all $p < .0005$), with the auditory condition producing the highest average workload ratings ($M = 77.512$, $SE = 2.541$), and the visual secondary task ($M = 65.763$, $SE = 2.541$) producing higher ratings than the baseline condition (M = 49.211, SE = 2.541). This is shown in Figure 3.5.

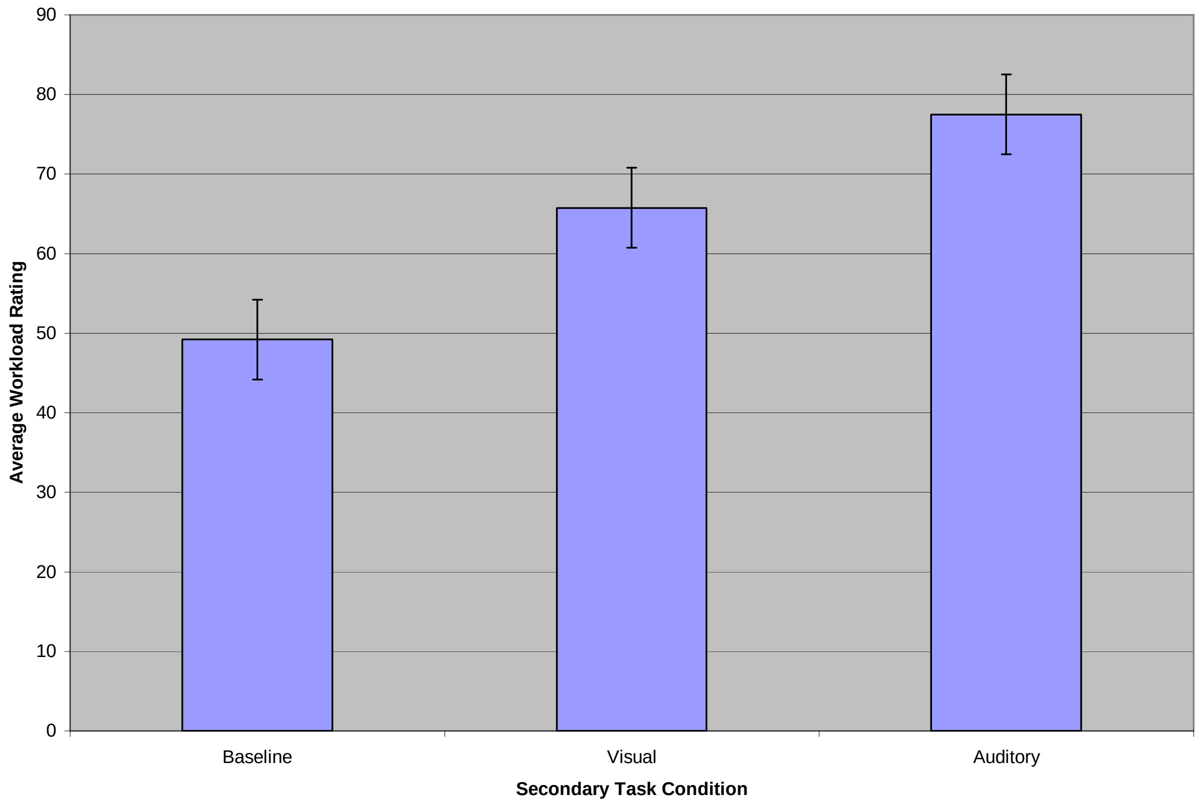


Figure 5 - Mean average workload rating as a function of secondary task condition

A closer analysis of the NASA-TLX data revealed that there were other differences between the conditions. Main effects were found for the raw mental demand, $F\ (2, 116) = 15{,}587$, $p < .0005$, $\eta^2 = .212$, physical demand, $F\ (2, 116) = 4.824$, $p = .01$, $\eta^2 = .077$, temporal demand, $F\ (2, 116) = 18.943$, $p < .0005$, $\eta^2 = .246$, effort, $F\ (2, 116) = 27.897$, $p < .0005$, $\eta^2 = .325$, and frustration, $F\ (2, 116) = 8.102$, $p = .001$, $\eta^2 = .123$. Performance was not found to be affected by secondary task condition (raw: $p = .112$; weighted: $p = .845$). These same main effects were also found for the most of the weighted scores, except physical demand ($p = .201$) and frustration ($p = .055$).

Experiment 1 - Discussion

The average threat response increased when participants had to perform a second task. This is interesting because it seems to be a compensatory effect, since there is no difference between the two secondary task conditions. It could be that the adjustments raise the threat level in order to be on the safe side.

As expected, participants responded to the pictures faster when they did not have to worry about a second task. It is interesting, however, that the slowest responses were associated with the auditory secondary task. Traditional multiple resource theories would suggest that the slowest responses would be found in the visual secondary task condition, from the use of visual attentional resources by both tasks. While the two visual tasks were not significantly taxing enough so as to cause the observers to have task failures, the secondary task did cause performance changes in the primary task.

The difference between the current task and traditional modality modulated dual task paradigms is the inclusion of emotional stimuli. It could be that when experiencing an emotionally driven stimulate on one sensory channel, the other channel is clear to prepare for information that can support response to the emotional stability. The response time trend seen in the primary task is also seen in the secondary task, lending additional strength to the confirmatory search hypothesis. This confirmatory search question will be considered again in the second experiment.

The number of errors in the secondary task was nearly 4 times higher when in the dual task auditory condition. This pattern is similar to the response time pattern of the secondary task. So, in the auditory dual task condition, participants made more errors and responded slower to secondary tasks than in any other condition. One potential reason for this may be that the secondary task stimuli did not have any associated emotionality. The emotionality component of the second task will be investigated in the second experiment.

The workload ratings present some interesting findings. While the significance of the mean raw physical workload rating leads to a question of the NASA-TLX's validity, that significance is mitigated when looking at the weighted rating scores. The task should not have been physically taxing. The participants seemed to realize that there was something different about the conditions, though they realized that the physical load was not an important contributor to the workload that they experienced.

CHAPTER FOUR: EXPERIMENT 2

Experimental Method: Experiment 2

Experimental Independent Variables

Based on the results from the first study, where the auditory secondary task was related to the worst task performance on the primary task, the second experiment investigated the interaction between stimulus modality and threatening stimuli with two concurrent tasks. The question of whether the same pattern of results would be seen when the threat-related task was auditory and the secondary task was visual needed to be answered. Therefore, there were three task-based independent variables: 1) task modality (visual, auditory); 2) task threat (threat, non-threat); 3) and inter-stimulus interval (No ISI, 500ms ISI with picture first, 500ms ISI with sound first, 1000ms ISI with picture first, 1000ms ISI with sound first). The reason for the inter-stimulus interval is to determine whether threatening stimuli are processed automatically or if they are subject to deeper cognitive processing, so a perceptual refractory period paradigm was chosen to test this.

Participants

Participants were 24 male cadets from the United States Military Academy, ranging in age from 18 to 21. This number was selected based on the manipulations required for the design to account for moderate levels of power (Cohen, 1992). They were drawn from first-year cadets enrolled in the Psychology for Leaders course. Participants received extra credit in the course for their participation.

Experimental Tasks

Participants were given two tasks to be performed concurrently, where one was visual and one was auditory. The visual task varied between threat-associated stimuli, which are the photos from the first experiment, and non-threat stimuli, which are landscape images. The auditory task was an auditory identification task. The stimuli will vary between threat-associated stimuli, which was rifle fire from either a M-16 rifle or an AK-47 rifle, and non-threat stimuli, which was two bird calls. Regardless of modality, each stimulus was presented for 500 ms.

Both tasks required key press responses from the participant. The participants were required to respond to each stimuli, regardless of threat or modality, before any successive trial was presented. Since it is possible that any trial without a response may be either an error of omission or a correct rejection, the required response strategy was chosen in order to clear any potential confusion.

Experimental Dependent Variables

For all but the threat-related visual stimuli, response accuracy was analyzed. The threat-related visual stimuli did not have true correct and incorrect answers, thus making them fuzzier in nature. So, mean number of “threat” responses were analyzed in the conditions which had the threat-related visual stimuli. Response time was also analyzed for each condition. Subjective workload was assessed using the NASA-TLX, yielding perceived general workload ratings.

Research Design

This experiment used a within-subjects design with 2 types of task modality (visual, auditory), 2 types of task threat (threat, non-threat), and 5 types of inter-stimulus interval (No ISI, 500ms ISI with picture first, 500ms ISI with sound first, 1000ms ISI with picture first, 1000ms ISI with sound first). Data was drawn from two performance-based dependent variables, response selection and response time, and from the NASA Task Load Index (NASA-TLX: Hart & Staveland, 1988).

Experimental Hypotheses

- If threatening stimuli are processed automatically, then there shouldn't be any lag in threat/threat sets and, in fact, may lead to shorter RTs for the stimuli. From a self-preservation sense, threatening stimuli should be raised to the fore of the soldier's attention. The threatening stimulus should not be deeply processed, since every moment without a response has a cost.
- Threat conditions will cause an increase in overall workload, as compared with non-threat conditions. As evidenced in the threat literature (e.g. Baddeley), the perception of threat increases a person's subjective workload, so any tasks which have a threat component to them should increase workload more than tasks that do not have a threat component.

Experimental Procedure

Data was gathered in two experimental meetings. The first meeting began with the participant completing the Informed Consent and Demographic Questionnaire forms.

Each trial in the session began with a blank screen for 1 second. A visual cue appeared on the screen for 200 ms prior to the first stimulus onset, regardless of modality. The two stimuli were then presented. Following the stimuli presentation, a set of questions asking the participant to give a confidence rating to their responses were given. This cycle continued for the length of the session.

Participants then practiced each of the tasks for five minutes. Response and response time information was gathered for each of the tasks to be used as baseline data. After practicing the tasks, the participant completed a NASA-TLX. Participants were randomly assigned to an order of the four conditions: Visual Threat - Auditory Threat (TT), Visual Threat - Auditory Non-Threat (TN), Visual Non-Threat - Auditory Threat (NT), and Visual Non-Threat - Auditory Non-Threat (NN). During the first session, participants were administered two of the four conditions, each of which was followed by the NASA-TLX.

The second session featured the other two conditions. Each condition was followed by a NASA-TLX. The participant finished the session with completion of the after-participation informed consent form as required by the United States Military Academy Human Subjects Review Board.

Results: Experiment 2

A 2 x 2 within-subjects multivariate analysis of variance was performed on five dependent variables: response to visual task, response time for visual task, response to auditory task, response time to auditory task, and subjective workload. The independent variables were threat (low and high) and presentation modality (visual and auditory). Tukey's Least Significant Difference (LSD) was used for post-hoc testing, unless otherwise stated.

Results for Inter-Stimulus Interval Manipulation

For response time to images, a main effect was found for inter-stimulus interval, $F(4, 366) = 2.584$, $p = .037$, $\eta 2 = .03$. Post hoc analysis revealed that response time was significantly slower when there was no inter-stimulus interval ($M = 1070.497$ ms, $SE = 33.426$) than when there was an ISI (all $p < .0005$). Additionally, while there was no significant difference between conditions when the image was presented first (1000 ms ISI, $M = 855.582$, $SE = 28.128$; 500 ms ISI, $M = 830.283$, $SE = 21.829$), they were both significantly slower than the conditions where the sound was presented first (500 ms ISI, $M = 685.267$, $SE = 14.489$, $p < .0005$; 1000 ms ISI, $M = 632.295$, $SE = 13.493$, $p < .0005$), with the 1000 ms inter-stimulus interval with the sound first condition giving significantly faster response times ($p < .0005$) than the 500 ms sound first condition. These differences are shown in Figure 3.6.

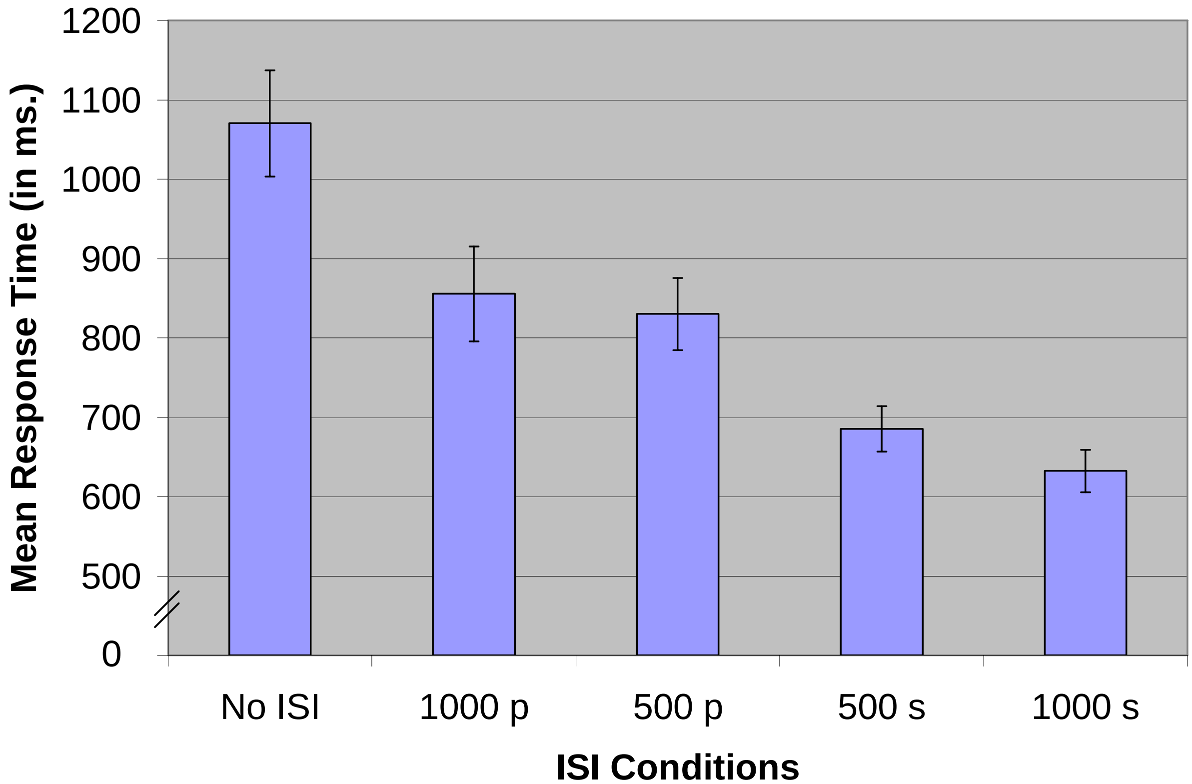


Figure 6 - The effect of inter-stimulus interval on mean response time to images

For response time to sounds, a main effect was found for inter-stimulus interval, $F(4, 366) = 3.673$, $p = .006$, $\eta^2 = .042$. Post hoc analysis revealed that response time was significantly slower when there was no inter-stimulus interval ($M = 1098.736$, SE = 37.362) than when there was an ISI (all $p < .0005$). Additionally, while there was no significant difference between conditions when the image was presented first (1000 ms ISI, M = 633.824, SE = 14.059; 500 ms ISI, M = 623.578, SE = 16.079), they were both significantly slower than the conditions where the sound was presented first (500 ms ISI, M = 530.843, SE = 13.535, $p < .0005$; 1000 ms ISI, M = 526.52, SE = 13.797, $p < .0005$), though there was no significant difference in response time between the two sound first conditions. These differences are shown in Figure 3.7. Both the image and sound response times follow a similar pattern. This pattern is most apparent in Figure 3.8.

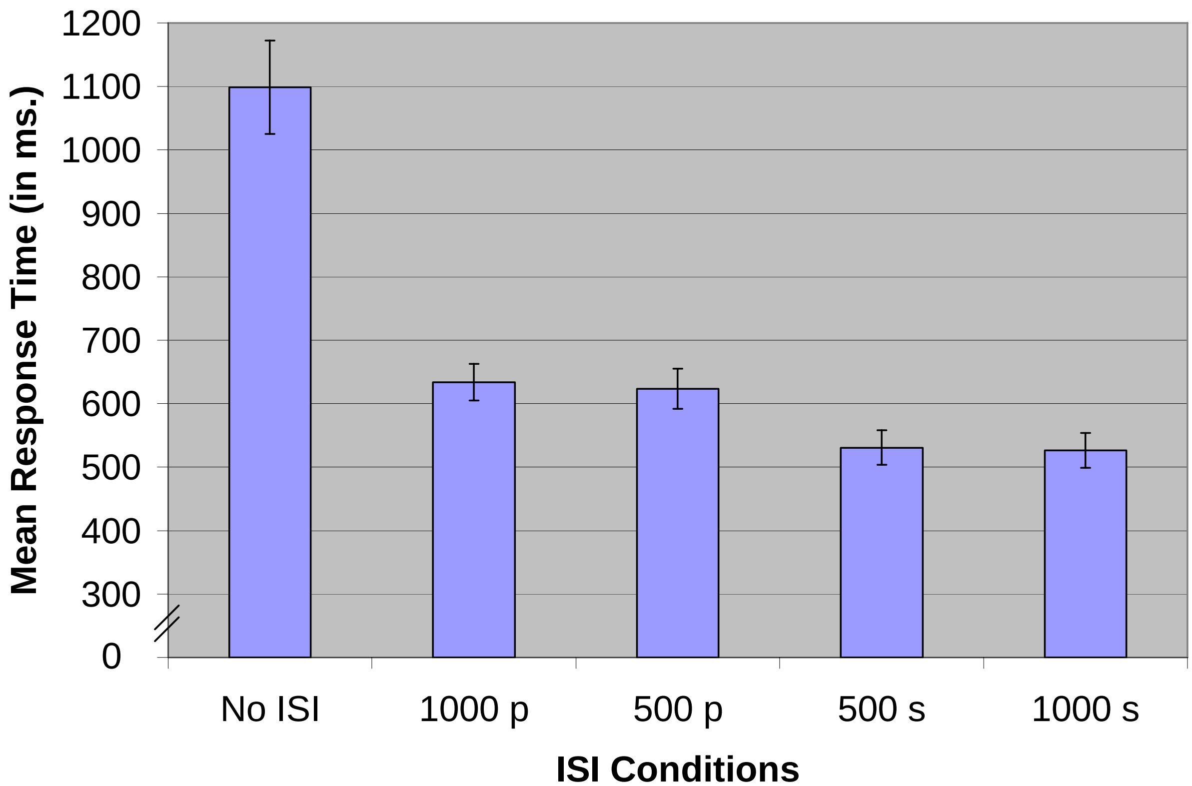


Figure 7 - The effect of inter-stimulus interval on mean response time to sounds

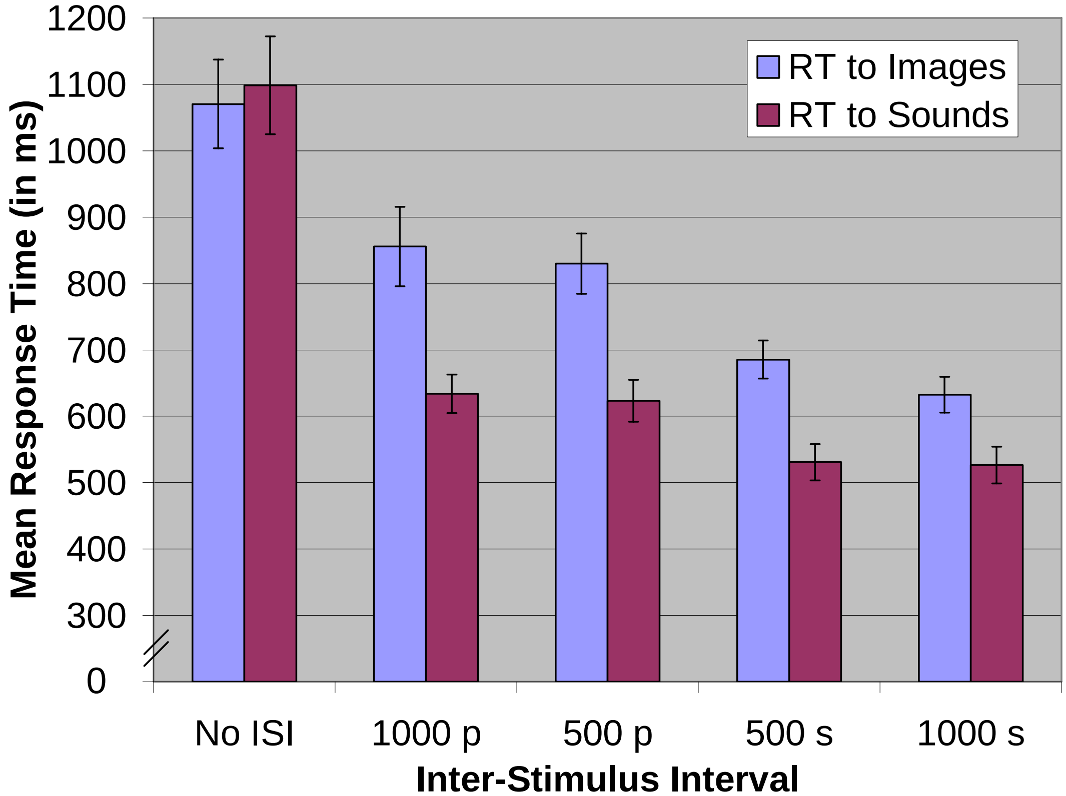


Figure 8 - The effect of inter-stimulus interval on mean response time to both images and sounds

Response Accuracy

Additional analysis was performed on the response accuracy to the sounds and images themselves. A main effect was found for the effect of inter-stimulus interval on the percentage of correct responses to the landscape images, $F(4, 184) = 12.192$, $p < .0005$, $\eta^2 = .21$. Post hoc analysis revealed that there was a significantly higher percentage of correct responses when there was no inter-stimulus interval ($M = 34.0625$, $SE = 2.471$) than when there was any ISI (all $p < .005$). Additionally, while there was no significant difference between conditions when the image was presented first (1000 ms ISI, $M = 25.21$, $SE = 2.141$; 500 ms ISI, $M = 24.69$, $SE = 2.096$), they both produced significantly more hits than the than the condition where the sound was presented 500 ms prior to the picture ($M = 27.81$, $SE = 2.237$, $p < .05$), though there was no significant difference in hits between either the two sound first conditions or the image first conditions with the 1000ms sound first condition ($M = 26.25$, $SE = 2.098$). These differences are shown in Figure 3.9.

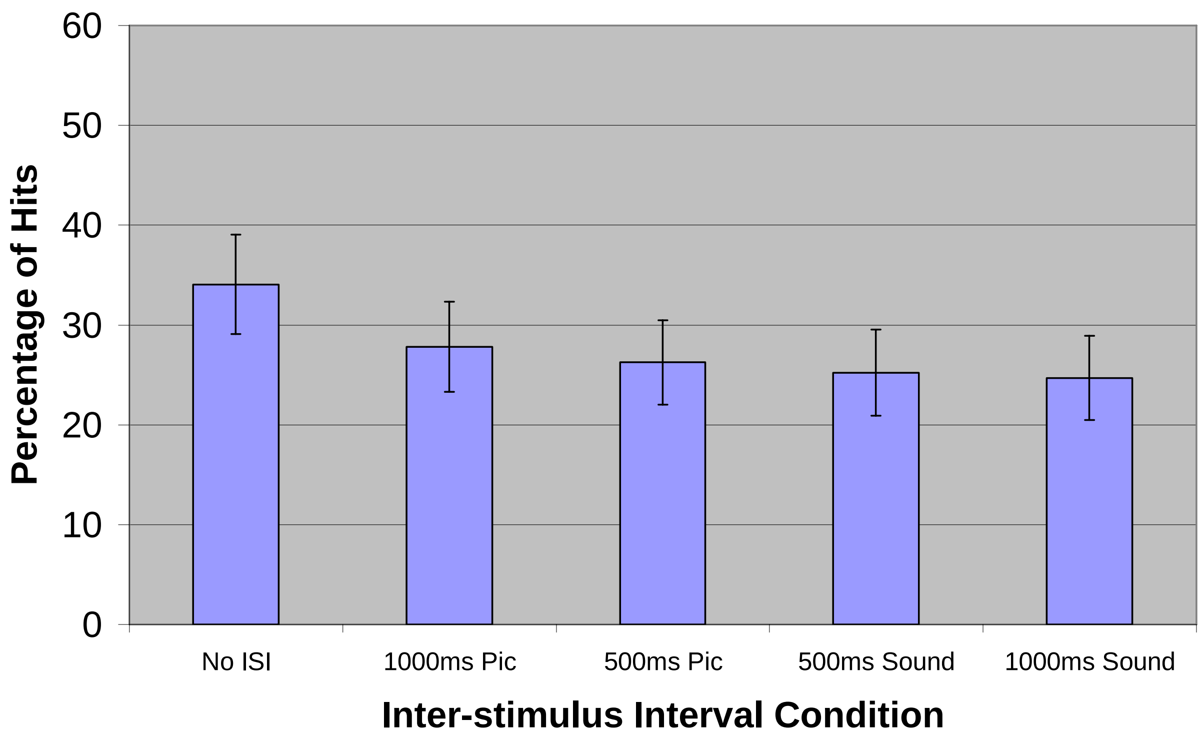


Figure 9 - The effect of inter-stimulus interval on mean number of hits to non-threat images

A difference was found between the two threat conditions for the percentage of the images of people that were regarded as threats, $F(1, 46) = 15.63$, $p < .0005$, $\eta^2 = .254$. In this case, the rifle fire auditory task ($M = 64.415$, $SE = 2.45$) was associated with a tendency to increase the level of threat attributed to the person in the picture, when compared to the bird call auditory task ($M = 50.71$, $SE = 2.45$).

A main effect was found for the effect of inter-stimulus interval on the percentage of correct responses to the sound stimuli, $F(4, 368) = 13.114$, $p < .0005$, $\eta^2 = .125$. Post hoc analysis revealed that there was a significantly higher percentage of correct responses when there was no inter-stimulus interval ($M = 74.53$, $SE = 1.959$) than when there was any ISI (all $p < .005$) except for the 1000ms sound first condition, which neared significance ($M = 70.677$, $SE = 2.02$, $p = .06$). Additionally, while there was no significant difference between conditions when the image was presented first (1000 ms ISI, $M = 62.71$, $SE = 2.408$; 500 ms ISI, $M = 65.57$, $SE = 1.963$) and the 500 ms sound first condition ($M = 64.32$, $SE = 2.316$), they both produced significantly fewer hits than the 1000 ms sound first condition (all $p < .003$). These differences are shown in Figure 3.10.

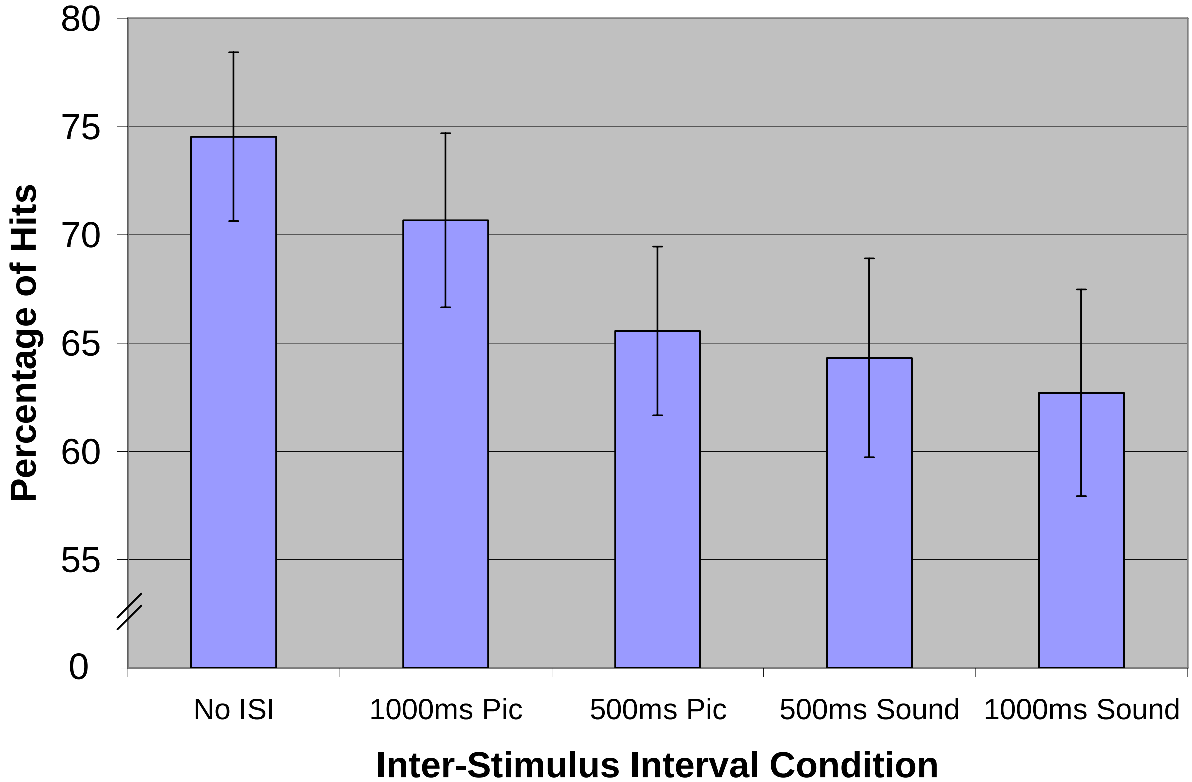


Figure 10 - The effect of inter-stimulus interval on the percentage of correct responses to sound stimuli

Results for Threat Manipulation

For response time to images, a main effect was also found for threat, $F(1, 86) = 9.995$, $p = .003$, $\eta^2 = .087$, with mean response times being faster for threat related visual stimuli ($M = 762.228$, $SE = 166.023$) than for non-threat related visual stimuli ($M = 863.9226$, $SE = 166.556$).

Additionally, there was a significant interaction between threat and modality of stimulus, $F(3, 84) = 4.819$, $p = .004$, $\eta^2 =$

.147. Post hoc analysis revealed that response time was significantly slower when neither the visual nor the auditory stimuli was threat related (NN: M = 891.353, SE = 32.678) than when threat related visual stimuli were presented with non-threat related auditory stimuli (TN: M = 721.6, SE = 32.57 $p < .0005$), though it did not significantly differ from either the condition with threat related visual and auditory stimuli (TT: M = 803.831, SE = 32.655) or the non-threat related visual and threat related auditory condition (NT: M = 842.356, SE = 32.62). The threat related visual paired with the non-threat auditory condition also differed significantly from the non-threat related visual and threat related auditory condition ($p = .01$). These differences are shown in Figure 3.11.

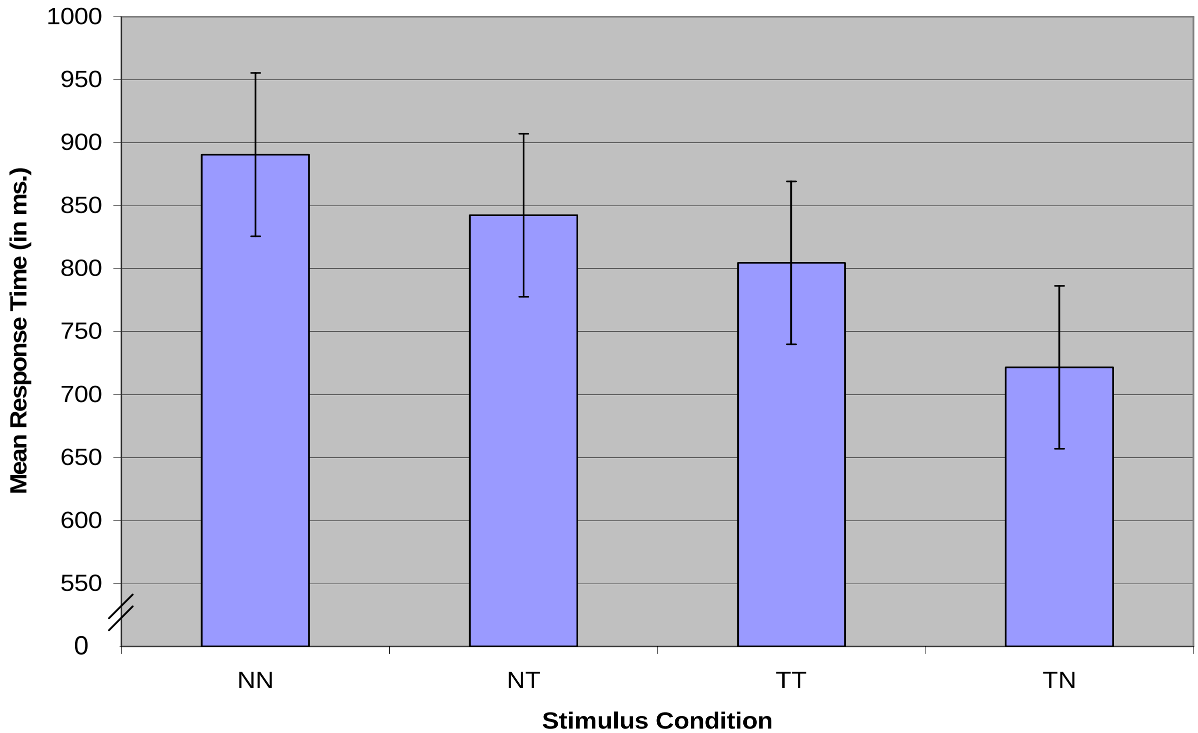


Figure 11 - The effect of threat and stimulus modality on mean response time to images

A main effect was also found for threat on the number of correct responses in the landscape image stimuli conditions, F $(1, 46) = 192.934$, $p < .0005$, $\eta^2 = .807$. The rifle fire condition ($M = 39.75$, $SE = 2.811$) produced a significantly higher percentage of correct responses than did the bird call condition ($M = 15.46$, $SE = 2.811$).

Results from Subjective Workload

A significant main effect was also found for secondary task condition on average workload rating given on the NASA-TLX, $F(3, 92) = 29.866$, $p < .0005$, $\eta^2 = .493$. Post hoc analysis revealed that all of the conditions were significantly different (all $p < .02$), with the TT condition producing the highest average workload ratings ($M = 77.249$, $SE = 3.193$), followed by the TN ($M = 66.410$, $SE = 3.193$), NN ($M = 55.495$, $SE = 3.193$) and NT conditions ($M = 36.342$, $SE = 3.193$). This is shown in Figure 3.12.

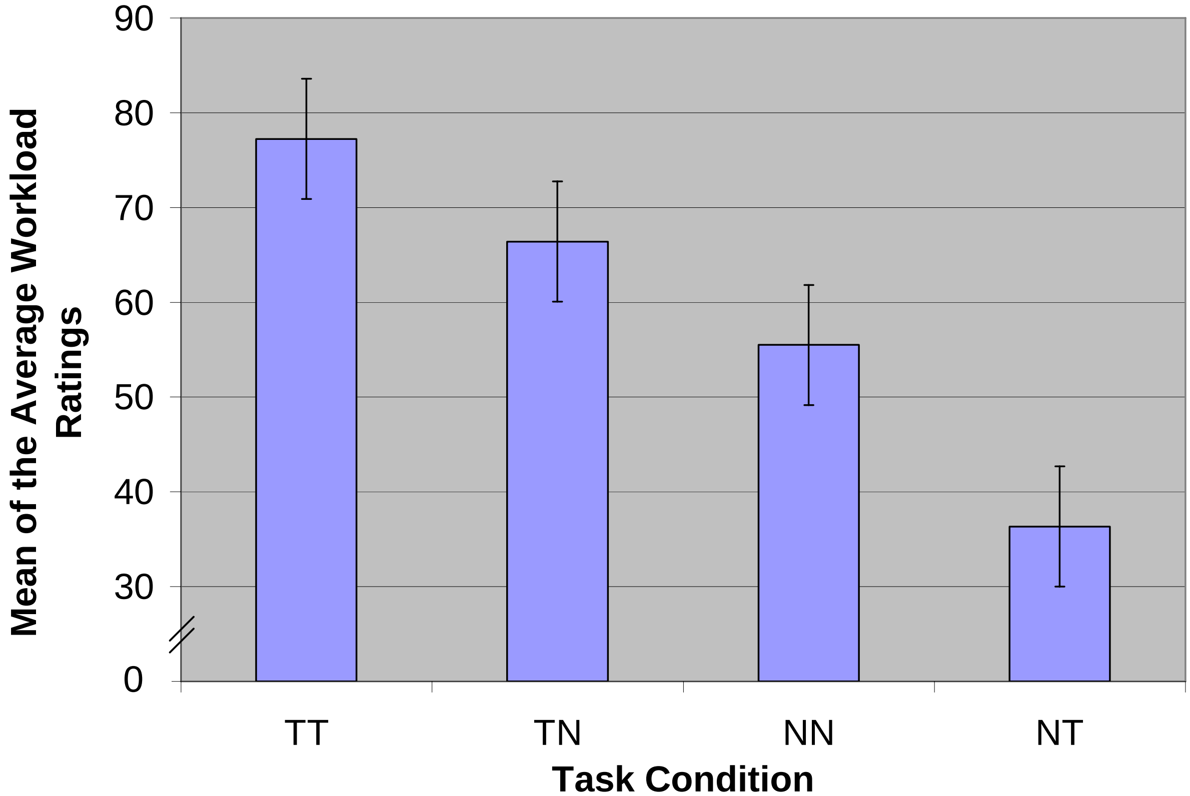


Figure 12 - The effect of task condition on mean average workload ratings

A closer analysis of the NASA-TLX data revealed that there were other differences between the conditions. Main effects were found for the raw mental demand, $F\ (3,\ 92) = 12.289$, $p < .0005$, $\eta^2 = .286$, physical demand, $F\ (3,\ 92) = 3.624$, $p = .016$, $\eta^2 = .106$, temporal demand, $F\ (3,\ 92) = 10.677$, $p < .0005$, $\eta^2 = .258$, performance, $F\ (3,\ 92) = 4.646$, $p = .005$, $\eta^2 = .132$, effort, $F\ (3,\ 92) = 12.579$, $p < .0005$, $\eta^2 = .291$, and frustration, $F\ (3,\ 92) = 7.21$, $p < .0005$, $\eta^2 = .19$. These same main effects were also found for the most of the weighted scores, except physical demand (p = .26) and performance (p = .661). Figures 3.13 through 3.22 illustrate these differences.

Experiment 2 – Discussion

In the second experiment, a similar outcome pattern was seen for the inter-stimulus interval condition between response times towards the images and response times towards the sounds. In both graphs, the slowest response times are associated with the no inter-stimulus interval manipulation, followed by the two manipulations where the images are presented first, and the fastest response times being associated with the manipulations where the sounds are presented first. While the slow response times in the no ISI manipulation is unsurprising, the pattern for image first and sound first is.

The differences in response time are more pronounced when participants are responding to images. While they do follow the same trend that the responses to sounds follow, the slope of the line between the clusters is greater for the image responses. The image responses are slower when the image is presented first. This would seem to indicate that the sounds, when they are presented first, serve to cue the participant and thus reduce response time to the images. The images, however, do not seem to serve the same function for the sounds, resulting in slower response times to the sounds than when the sound is presented first.

CHAPTER FIVE: GENERAL DISCUSSION

Experiment 1

The results from the first experiment supported the hypothesis that the ratings of threat increased when participants were involved in the dual task conditions. This makes sense, since there are many cases in everyday life where we will err on the side of caution when we are subject to overload (Bodenhausen & Lichenstein, 1987; Dijker & Koomen, 1996; Kruglanski & Freund, 1983). One example can be seen in the tendency of drivers to allow more headway between their vehicle in the vehicle front of them when they are engaged in tasks other than driving (Noy, 1989).

Another possible reason for the higher threat ratings might be that the participant did not have the time to allocate to a thorough inspection of each threatening stimulus and, until they can give each stimulus this thorough inspection, they rate the stimulus as more threatening in order to "play it safe." The drawback of this is that the soldier would be more likely to enact a response to a stimulus that did not pose a threat, and potentially causing an incident. This form of behavior is equivalent to setting a more liberal criterion (or β) in classical signal detection (Green & Swets, 1974; Macmillan & Creelman, 1990). This difference seems to emerge solely from the need to accomplish two tasks simultaneously, not from the nuances of load change, per se. If there were consequences to their actions, observer ratings might not have been so different. The ecological validity of this study takes some strength away from this conclusion, so verification in a more externally valid context is required.

The data from the first experiment ran opposite to the initial hypothesis that the higher threat ratings would be associated with the visual-visual dual task condition. In fact, the highest threat ratings were found in the dual task visual-auditory condition. At first blush, this would seem to directly contradict Wickens' Multiple Resource Theory (Wickens, 1980; 1984) which would indicate that two tasks that both draw from the same resource pool should show greater performance interference (Wickens, 2002). However, a plausible alternative explanation may exist. It may be that threatening stimuli are encoded using resources from the auditory pool or are processed using auditory channels. While there does not seem to be any additional research to support this claim, it poses a question that has not really been considered in psychology. That is, can factors besides the modality of a stimulus dictate how the stimulus is processed. An alternative to this is that, when presented with a visual stimulus that is perceived as threatening, the observer clears their auditory channel in an effort to gather additional information on the potential threat. This is seen in cases where an organism hears a sound that wasn't expected, so it begins to look around for additional, confirmatory information (Seagull, 2002).

It is also interesting to note that an increased number of errors and slower response times were associated with the auditory task in the dual task visual-auditory condition, giving further weight to the idea that emotional encoding may occur at least partially in the same way as auditory stimuli. If this is indeed the case, then modality of stimulus may not be the only predictor of dual-task interference. This usage of modality-related resources would not necessarily require that the stimuli be perceptually chunked. It may be that there is no "emotional" reservoir for resources, so they may be drawn from secondary sensory stores. This would probably not occur with visual resources, since research has shown that humans give a greater amount of attention to visual information (Colavita, 1974; Klein & Posner, 1974; Pick, Warren, & Hay, 1969; Posner, Nissen, & Klein, 1976) and it is harder to draw attention away from visual focus (Klein & Posner, 1974; Posner, 1967).

The data from the first experiment also revealed that the dual task conditions were associated with an increase in overall workload ratings, as gathered from the NASA-TLX (Hart & Staveland, 1988). The significant difference between the two dual task conditions in which the visual-auditory condition showed significantly higher average workload ratings than the visual-visual condition, however, was unanticipated. It would seem that the dual task visual-auditory condition, where the visual stimulus is threat-related, is associated with unforeseen increases in workload. This increase in workload may reflect attentional switching between the two modalities (De Jong, 2000; Wylie & Allport, 2000). If it is the case that the processing of threatening stimuli interferes with auditory processing, however, then it would seem logical that the highest levels of workload would be associated with the dual task condition involving auditory processing.

When seen with the other patterns of data for the dual task condition, it seems to lend additional support to an auditory bottleneck occurring during the processing of threatening stimuli. In both response time to the threat related stimuli and in subjective estimates of workload, the associated change in response time performance was mapped to a comparable change in workload, as seen in Figure 4.1. This is evidence of direct association and argues for the veracity and reliability of the finding.

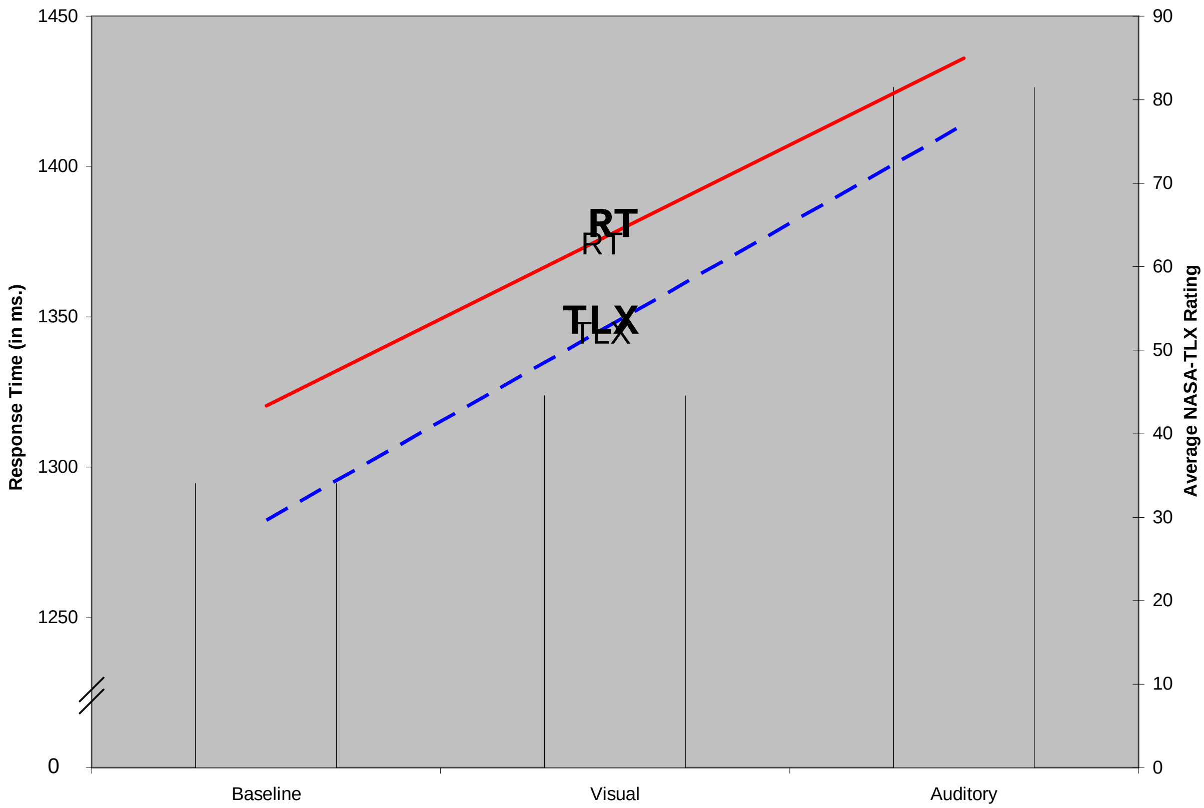


Figure 13 - Linear relationships between the secondary task condition for response time to the primary task and average NASA-TLX rating

Experiment 2

Response times in the no inter-stimulus interval condition were markedly longer as compared to any of the other inter-stimulus interval manipulations. There was no interaction between threat and inter-stimulus interval, so there was no difference between the threatening and the non-threatening stimuli. This is indicative of a processing bottleneck or a capacity limit in the shared central processing of the two stimuli (Ferreira & Pashler, 2002; Tombu & Jolicoeur, 2005) and indicates that threatening stimuli are not processed automatically. This is a significant finding given the evolution of threat assessment in organisms. It would not seem to be a beneficial adaptation. Organisms would be best served by having perceived information that is threat related come to the fore of attention and be processed as quickly as possible. If this was not the case, that organism would presumably cease to be the fittest. Human beings, however, have protected themselves for quite sometime.

It could be argued to be a failure of the stimuli to elicit a threat reaction, that position is not supported by the workload data from this study. If the stimuli did not elicit a threat or danger response, workload would not be rated as higher in the visual threat related condition.

The no ISI condition was also associated with the greatest proportion of correct responses. While an argument exists for a potential speed-accuracy tradeoff (Fitts, 1966; Rabbitt, 1989; Seibel, 1972), this pattern is not carried through in the other conditions. The sound first conditions, for instance, produce the second highest proportion of correct responses, while producing the fastest response times. Thus, the increased response times seen in the no ISI condition may provide the necessary additional processing time because of the possible bottleneck. If this is indeed the case, then the bottleneck may exist in the response portion of the SCR chain.

While the response times to the stimuli that were presented first did vary by modality (images = 832.9325 ms; sounds = 528.6815 ms) as seen in Figure 4.2, there was no significant difference between response times to the stimuli that were presented second regardless of modality, shown in Figure 4.3. This is interesting, since it indicates a speeded response to the images, when they are presented after the sounds. The sounds could serve as cue for the images, but this is unlikely given the fact that a visual cue was presented on the screen prior to all trials to signal the beginning of the trial.

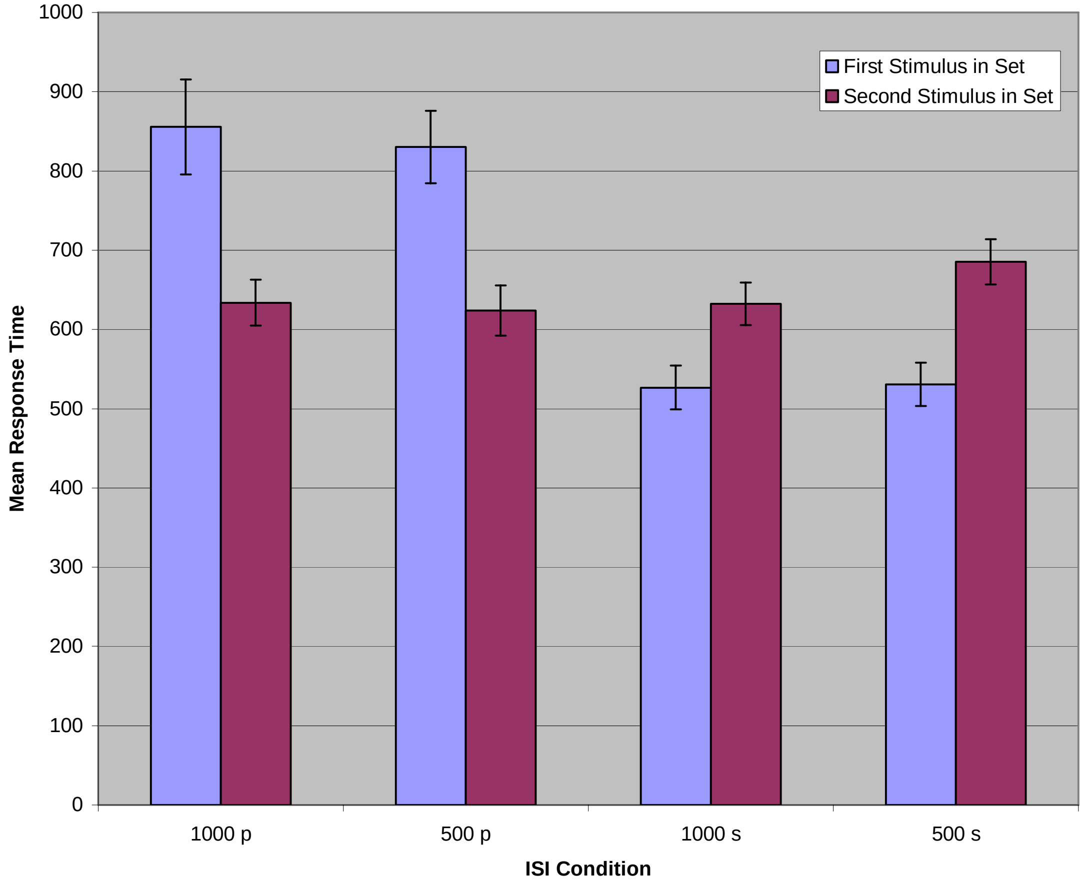


Figure 24 - Mean response time as a function of inter-stimulus interval condition and stimulus chronological position

It also indicates that responses to sounds, when they follow images, are slowed. This may signal a problem with attentional transfer from images to sounds. This explanation is unlikely, though, because the 500 ms ISI condition where the image is presented first has an overlap between the response to the image and the onset of the sound of about 330 ms. If there was an attentional transfer problem, a lag in response would be apparent here. Instead, participants seemed to be able to process both stimuli at the same time, if only for a short period. This may be possible because the stages of processing for the two stimuli are at different places. Another explanation may be that the first stimulus, regardless of modality, raises the participant's level of arousal above threshold, thus mitigating any modality-related response time disadvantages.

The threat-threat condition did show significantly higher subjective workload ratings than any of the other conditions, though it did not seem to facilitate either response accuracy or response speed. This illustrates an overload which, given no other change in task besides threat, indicates additional effort being devoted during the processing of threatening stimuli. From an evolutionary point of view, devoting more effort towards situations may compensate for the fact that the threatening stimuli are not processed in an automatic manner. So, if the organism is unable to process threatening stimuli automatically, it instead devotes more attention and effort than normal to the processing of that information which will facilitate response.

While the threat/threat condition was connected with the highest workload ratings, the lowest workload ratings were found in the no threat/threat condition. This also matches with the assertion that observers were focusing a great deal of resources on the monitoring of the threat-related stimuli. This all makes sense, given the fact that threats must be appraised.

It is interesting to note that the manipulation of threat did not affect responses to the auditory task, though the visual task was affected by the manipulation of threat in the auditory task. While it may be the case that the auditory stimuli were more emotionally charged for the participants than the images, the findings may be connected to the results of Experiment 1. The rifle fire may also trigger a threat readiness response on the part of the observer, leading to a greater number of “threat” responses to the images of the people.

CHAPTER SIX – PRACTICAL IMPLICATIONS, SUMMARY, AND CONCLUSIONS

Practical Implications

While soldiers may be able to process information from multiple sources at the same time, it will most likely be to the detriment of those around them. Participants rated people that they observed in pictures as more threatening when they were engaged in an additional auditory task. Their response time in cases where both the picture and the sound were threat related was also on average the second fastest of the conditions. This means that soldiers will most likely be hasty in their decisions regarding the threat posed by someone that comes into their field of view if they are hearing rifle fire, potentially leading to a "shoot first, ask questions later," situation. An error like this can have some very serious repercussions. These repercussions can manifest as diplomatic issues, as in the Sgrena incident, or as strategic issues, restricting certain courses of action for future operations.

Task shedding is often out of the question in most dual-task threat assessment scenarios. This is because the period of time that the soldier has to process and respond to the potential threat is short and because the other tasks are often essential.

A preliminary solution would seem to be in the realm of training. If soldiers are told that their threat assessments will change when they are involved in multiple tasks, they may be able to adjust the gain on their threat sensitivity accordingly (Wickens, 1986). This presents a risk, though. What if the threat gain is adjusted too much? In this situation, the soldier would themselves be at risk, not responding to a threat and leaving themselves vulnerable.

Another solution would be to make adjustments to the soldier’s processing ability. While it was mentioned above that task shedding would be unrealistic in this scenario, an adaptive system could potentially shift the task allocations more quickly than the human could himself. The DARPA AugCog (Augmented Cognition) program is seeking to find the limits of human processing abilities, measure those abilities, and incorporate the results into dynamic sensor systems (Schmorrow & McBride, 2004). The goal of this program is to build systems with assistive automation that automatically implements itself at different levels of participation, depending upon the performance needs of the operator. In the case of the multitasking soldier, the system could note the change in load and adjust the flow of additional task information, thus allowing the soldier to allocate more attention to the potential threat.

As a counter-point, it may be that shedding additional tasks is the ideal strategy in a particular situation. In this case, the soldier is putting an high priority on potential threats in the environment. In certain cases, this would be the best strategy. So, training procedures could also include information on how to assess a situation at a higher level to determine whether focus on that threat assessment task is necessitated.

Summary and Conclusions

It appears that judgments of perceived threat can be affected by engaging in more than one task at a time. Specifically, soldiers regarded people as more threatening when they themselves were engaged in an additional task at the same time. While this may be precautionary in nature, it still raises concerns over what happens in cases where the soldier is unable to return to the potential threat to perform a reassessment. It is understood that combat does not afford the ideal length of time to perform unaffected threat judgments on everyone that a soldier comes into contact with. It is also understood that soldiers are often unable to load shed any additional tasks that they are asked to perform. This leaves a situation wherein soldiers must make a decision that will be both imperfect and potentially life-threatening.

This secondary task engagement also seems to be modality-specific. The auditory system bears the brunt of the positive or negative effects, presumably because threatening or potentially dangerous stimuli are processed utilizing structures commonly associated with auditory information. While it would be easy to suggest that the soldier just turn off their radio or stop a conversation they are having, this would be impractical. First, the soldier's decisions are made in a matter of a second or two, not nearly enough time to draw attention away from the auditory task.

Threat does not appear to be processed automatically. Thus, cognitive processing of appraised stimuli is actively required. Threat processing is subject to the same constraints as other stimuli when being processed simultaneously with other information. As stated above, it is not realistic to expect soldiers to cease other tasks when presented with a threat judgment task.

The relationship between threat and workload is moderated by the stimulus modality. In the second experiment, the modality of the threat stimulus was varied to determine whether the finding from the first experiment, that primary visual threat judgment tasks were affected by secondary auditory tasks, would also apply when the primary threat task was auditory and the secondary task was visual. This was not seen in the data, though. In fact, performance on the auditory threat judgment task was better overall. This would seem to reflect a much faster processing of the auditory information. The auditory task, while representing two types of rifle fire, may not have possessed the same amount of complexity as the visual threat perception task did.

APPENDIX A – INSTITUTIONAL REVIEW BOARD APPROVAL FORM

DEPARTMENT OF THE ARMY
UNITED STATES MILITARY ACADEMY
West Point, New York 10996

REPLY TO
ATTENTION OF

MAOP-R 29 August 2005

MEMORANDUM FOR MAJ Daniel R Smith, Coordinator, Department of Behavioral Science and Leadership

SUBJECT: Human Subjects Research Review Board (HSRRB) Approval of Proposed Research Protocol

1. References:

a. Department of Defense (DoD) Directive Number 3216.2 (dtd: 25 March, 2002), *Protection of Human Subjects and Adherence to Ethical Standards in DoD-Supported Research.*

b. Army Regulation (AR) 40-38, *Clinical Investigation Program.*

C. United States Military Academy (USMA) Regulation 70-1, *Research, Development and Acquisition.*

d. USMA Policy Memorandum Number 1-00 (dtd: 26 July, 2000), *Human Subjects Researxh Review Board (HSRRB), MEDDAC, West Point.*

2. The HSRRB at the United States Military Academy has determined that the following research proposals are "exempt" from the approval procedures outlined in the references above.

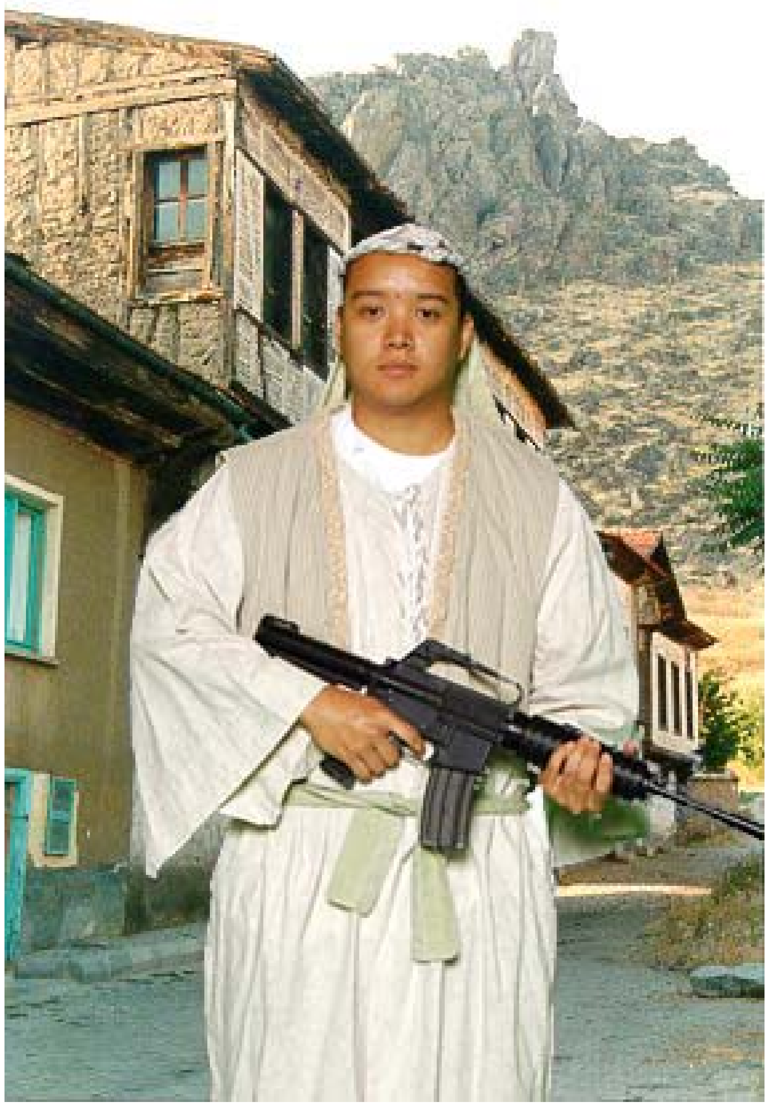
a. **The Effects of Modality and Expertise on Threat Assessment**

The principal investigators are free to conduct their research IAW their recent application memorandum submitted to the HSRRB.

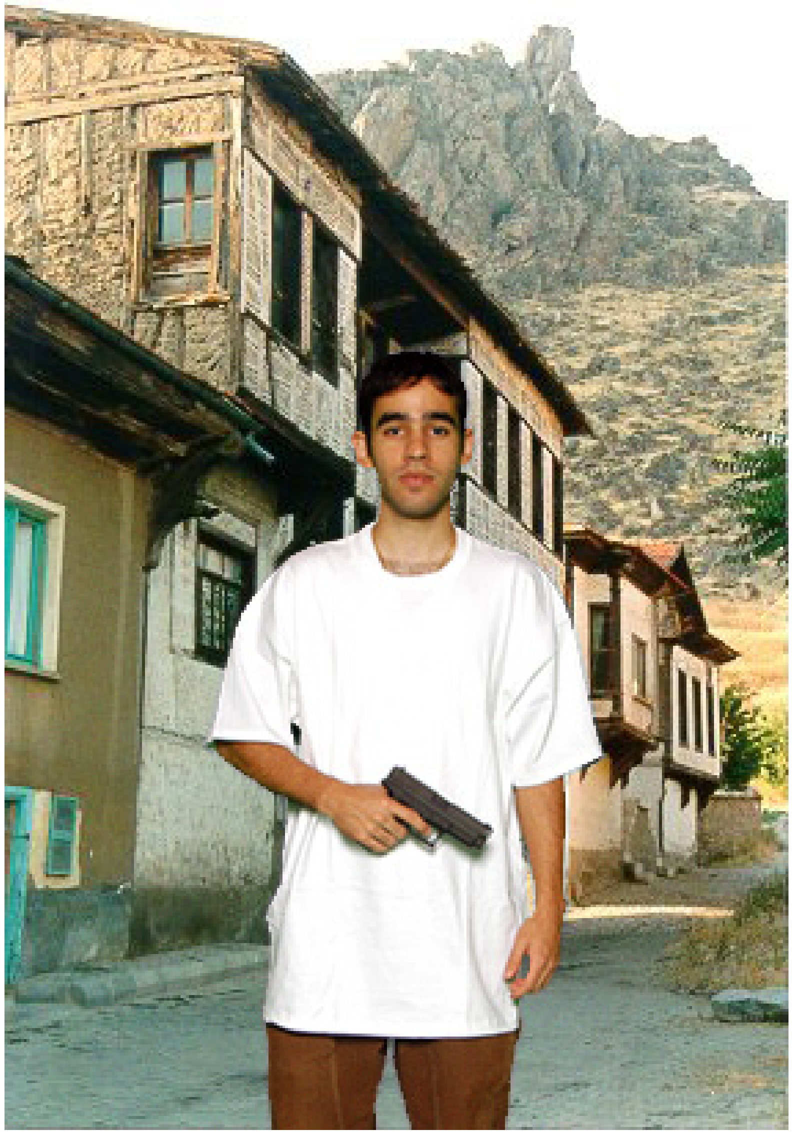
4. Point of contact for this memorandum is the undersigned at x7389.

//original signed//
MICHAEL J. JOHNSON
LTC, EN
Chief

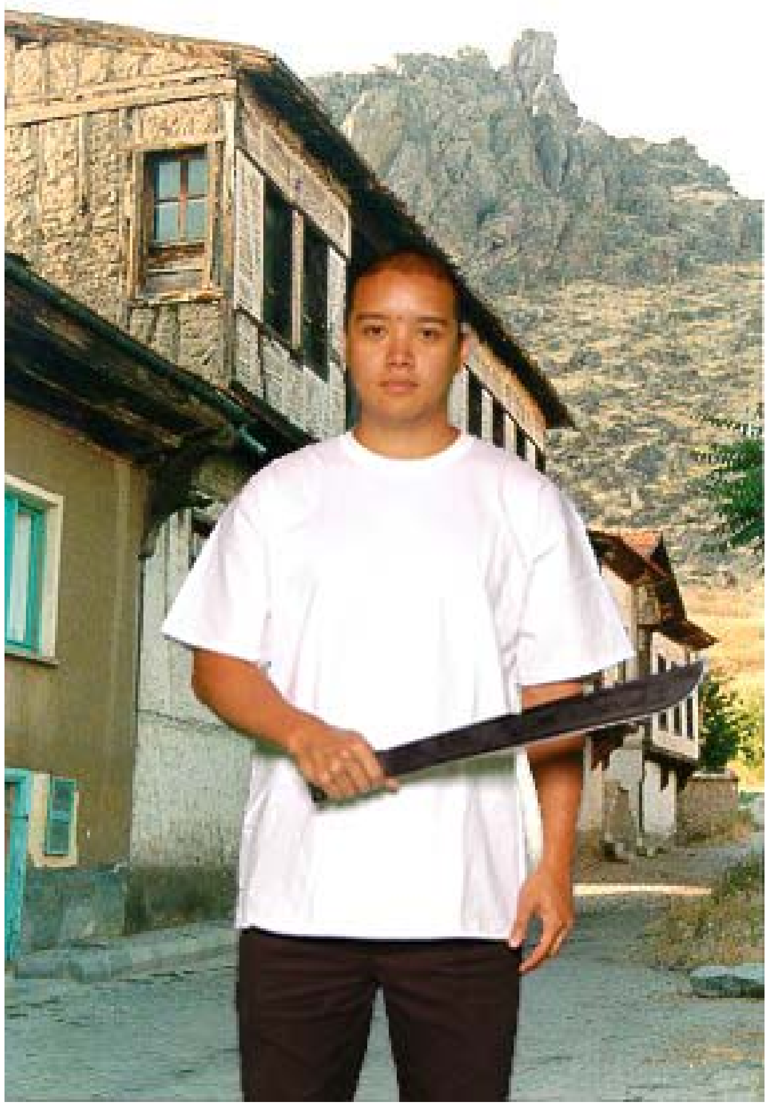
APPENDIX B – EXAMPLE IMAGES FROM THE VISUAL THREAT TASK



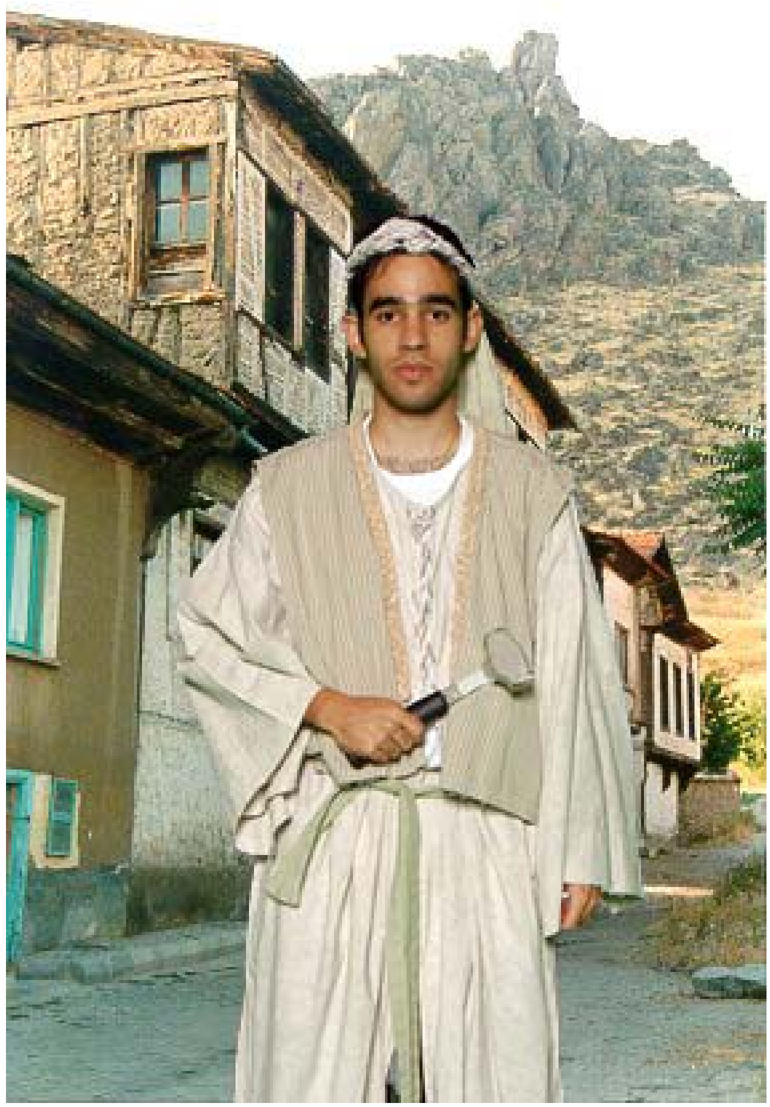
Male in eastern garb with a rifle



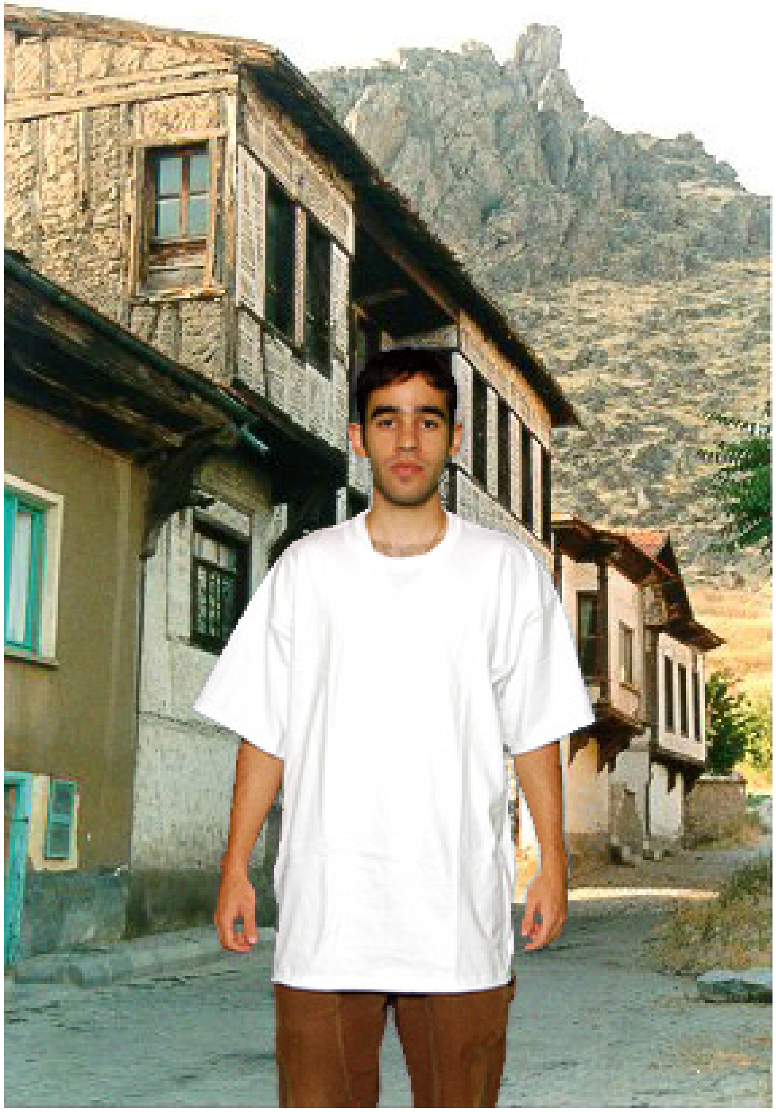
Male in western garb with a pistol



Male in western garb with a machete



Male in eastern garb with a mallet



Male in western garb with nothing in his hands

APPENDIX C – EXPERIMENTAL INFORMED CONSENT FORMS

Research Number:

INFORMED CONSENT (BEFORE PARTICIPATION)

I consent to participate in the research entitled

The Effect of Task Modality on Workload
and the Assessment of Threat

Conducted by H.C. Neil Ganey, University of Central Florida.

My task in the research is:

To simultaneously assess visual and auditory stimuli that are presented via a computer.

H.C. Neil Ganey (Principal Researcher/Supervisor) or his/her representative explained the procedure and the expected duration of my participation. I am aware that although no physical or psychological harm is anticipated, I may withdraw from participating in this project at anytime, without penalty. I am also aware that I chose to participate in this research instead of taking a laboratory exercise. I was informed that after my participation, I will be briefed about the purpose of the research.

I acknowledge that my participation is free and voluntary. I understand the personal information I provide and the data collected will be used for research purposes only. They will be treated confidentially and will not be accessible to anyone outside the research team. A copy of this consent form will be supplied to me at my request.

Date: ______________________________________

Printed Name: ______________________________ (Cadet)

PL100 Instructor Name & Section Number: ______________________________

Signed: ____________________________________ (Cadet)

Signed By: __________________________________ (Experimenter/Data Collector)

Research Number:

INFORMED CONSENT (AFTER PARTICIPATION)

I have completed participation in the above research project. My participation lasted _____ hour(s) and _____ minutes and I have been credited with ______ hour(s) of research time. The purpose of the research was:

To investigate the way that people assess threat when they are under different types of workload. The results of this work will lend to a further understanding of human information processing and may guide selection and training of those making assessments of threat.

I was fully debriefed regarding the purpose of this project. I was also given the opportunity to obtain further information about the research. All my questions have been answered to my satisfaction.

Date: ____________________________________

Printed Name: _____________________________ (Cadet)

Signed: ___________________________________ (Cadet)

Signed By: _________________________________ (Experimenter/Data Collector)

APPENDIX D – NASA TASK LOAD INDEX

Title	Endpoints	Descriptions
Mental Demand	*Low/High*	How much mental and perceptual activity was required (e.g. thinking, deciding, calculating, remembering, looking, searching, etc)? Was the task easy or demanding, simple or complex, exacting or forgiving?
Physical Demand	*Low/High*	How much physical activity was required (e.g. pushing, pulling, turning, controlling, activating, etc)? Was the task easy or demanding, slow or brisk, slack or strenuous, restful or laborious?
Temporal Demand	*Low/High*	How much time pressure did you feel due to the rate or pace at which the tasks or task elements occurred? Was the pace slow and leisurely or rapid and frantic?
Performance	*Good/Poor*	How successful do you think you were in accomplishing the goals of the task set by the experimenter (or yourself)? How satisfied were you with your performance in accomplishing these goals?
Effort	*Low/High*	How hard did you have to work (mentally and physically) to accomplish your level of performance?
Frustration Level	*Low/High*	How insecure, discouraged, irritated, stressed and annoyed versus secure, gratified, content, relaxed and complacent did you feel during the task?

Scales of the NASA Task Load Index (from Hart & Staveland, 1988, p. 168).

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