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Effects of Anxiety on Change Detection in a Command and Control Task

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Effects of Anxiety on Change Detection in a Command and Control Task

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Abstract

Air battle management (ABM) operations places high demands on operator attention; operators are required to manage an airspace cluttered with aircraft, identify changes in amity of entities and respond appropriately to these aircraft. Awareness of the severe consequence of errors in detection and the risk of physical harm may contribute to operator stress and anxiety. Anxiety research shows a selective attention bias to threat-related information which, according to attentional control theory, impairs the inhibition and shifting stages of executive functioning related to attention. In the ABM context, task anxiety may increase change blindness by interfering with attentional processes. The current study aimed to observe these effects in dyads performing a simulated ABM task. Participants controlled fighter aircraft to destroy incoming enemy planes and protect their own assets. General aims of the study were to distinguish the impacts of trait and state anxiety on detection of target aircraft differing in threat, and to test the role of anxiety produced by a mood induction. Forty-six individuals were pre-screened for inclusion based on low and high trait anxiety such that teams of low, mixed and high trait anxiety might be compared. All teams performed the task in both neutral and anxious mood conditions. This experiment utilized a 3 × 3 × 2 × 2 mixed-model design. The between-groups factor was team composition (low anxious, mixed anxious, high anxious). Within-groups factors included trial mood state (Neutral-1/Anxious/Neutral-2), time, and target amity (neutral, low-threat, high-threat). The dependent measures collected in this experiment included measures of offensive and defensive performance in the air battle management task, measures of change detection, and three subjective state measures including the Dundee Stress State Questionnaire (DSSQ), State-Trait Personality Inventory (STPI) and the NASA Task Load Index (TLX). Team × Time mixed-model analyses of variance (ANOVA) were run on all subjective state measures, i.e. state anxiety, stress state, and workload. Multiple $3 \times 3 \times 3$ (Team × Mood State × Target Amity) mixed-model ANOVAs were performed for change detection frequency and reaction time, number of enemies killed, time to prosecution, and attacks sustained. Additionally, correlational analyses were conducted for all subjective and objective dependent variables. As predicted, state anxiety was elevated by the anxious mood induction with increases in state anxiety accompanied by changes in distress. Also, higher state anxiety in high anxious teams provided partial support for the hypothesis that trait anxiety would elevate state anxiety. The hypothesis that threat level of change events would influence detection was supported. Offensive performance of ABM task improved with time, and defensive performance was poorer in low trait anxious teams. Understanding the effects of trait and state anxiety on change blindness and performance in ABM operations are complicated by the presence of multiple sources of stress inherent to the task. The results of this study suggest that there may be a benefit to trait anxiety in ABM operations. Team selection should consider optimizing the performance advantages associated with high trait anxiety.

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Air battle management (ABM) is the direction and implementation at the tactical level of operational air tasking orders, and involves the command and control[1] (C2) of air-to-air and air-to-ground operations (Vidulich, Bolia, & Nelson, 2004). Examples of ABM operations include the control of assets engaged in offensive and defensive operations, air refueling, and air mobility missions. Within the United States Air Force (USAF), one platform supporting ABM operations is the E-3 Sentry, an Airborne Warning and Control System (AWACS) aircraft, which provides the U.S. military with the surveillance, command, control, and communications needed for effective battle management.

ABM operations frequently require operators to manage an airspace cluttered with aircraft (it is not uncommon for these operators to simultaneously track 50 to 100 contacts of interest within a battlespace; DiVita, Obermayer, Nugent, & Linville, 2004) and accurately identify friendly and hostile entities. Upon detection of enemy forces, they must respond appropriately (e.g., by signaling friendly forces, intercepting hostile aircraft, etc.). As such, the nature of ABM operations place high demands on operators' working memory and attention, due to the visual and tactical complexity of the environment, which are likely to produce feelings of overwork and stress (Sterling & Perala, 2007). In addition to cognitive demands, awareness of the severity of a missed detection or false alarm, which may result in severe real-world consequences (e.g., loss of personnel and assets, fratricide, charges of negligence or dereliction of duty, etc.), is likely to increase the experience of operator stress. Operators also face the real threat of physical harm during combat operations, which is also likely to produce feelings of

[1]Defined as "the exercise of authority and direction by a properly designated commander over assigned and attached forces in the accomplishment of the mission" (Department of Defense Dictionary of Military and Associated Terms, 2001, p. 101).

stress and anxiety (e.g., Orasanu & Backer, 1996). Stress and anxiety may degrade operator performance (Matthews, Davies, Westerman & Stammers, 2000). However, response to stress is subject to individual differences (Hancock & Szalma, 2007) and, in the case of anxiety, may have specific effects on attentional processing. Anxiety impairs attentional control and if experienced in an ABM task, may increase the frequency of missed detections and result in casualty.

Stress and Anxiety in C2 Environments

Feelings of stress may arise from many sources, as illustrated in the context of USAF C2 environments, and in any form may undermine performance. Generally, stress arises when an event or object, the stressor, is appraised as potentially causing personal harm or threat, requiring the individual to cope. Thus stress is an emergent process of the individual and their perceived relationship with an environmental stressor which continuously evolves as coping strategies change perception of the stressor (Lazarus, 1993). The relationship between stress and performance is best explained in the language of information processing theory, which suggests that optimal performance and cognitive processing are dependent on mental resource availability (Hockey, 1997; Wickens, 1991). When confronted with a stressor, an individual may attempt to maintain their cognitive-affective state, and this expenditure of effort may pull resources away from task performance (Hancock & Warm, 1989; Hancock & Szalma, 2007). Environmental stressors, such as noise, heat, and task load, may increase the expenditure of resources (Hockey, 1997; Hancock & Szalma, 2007).

The stress process may generate a variety of responses including changes in subjective feelings, psychophysiological responses, and performance impairment. Lazarus and Folkman's (1984) transactional model of stress especially emphasizes the role of emotional states in the expression of psychological stress. Emotion results from perceptions of the impact a stressor might have on the individual (Lazarus, 1993). For example, in the context of a relationship, Lazarus (1993) states that an argument may cause either feelings of anger if the argument is seen as personally demeaning or feelings of anxiety if the argument is seen as an indication of threat to the relationship. Therefore, the stress process, or “stress reaction,” may vary based on which emotion (i.e., anger, shame, or anxiety) is experienced when encountering a stimulus because coping strategies vary across emotions (Lazarus, 1993). In the ABM context, emotional responses are likely to reflect how the operator appraises the threat posed by the enemy, and their choice of coping strategy. Although stress may generate multiple emotions (including positive emotions such as excitement), anxiety is of special importance because of evidence linking it to attentional impairments (Sarason, Sarason, & Pierce, 1990).

Anxiety is a common emotional state experienced by individuals in response to a threat. Freud first described anxiety as a transitory state marked by physiological symptoms such as heart palpitation, abnormal respiration, sweating and other autonomic nervous system responses (Freud, 1924, as cited by Spielberger, 1972). According to the transactional model of stress (Lazarus & Folkman, 1984; Lazarus, 1993), the emotional state of anxiety is the result of interpretation of one’s relationship to the environment as characterized by threat. Trait anxiety is a stable inclination to states of anxiety; state anxiety is associated with activation of the autonomic nervous system and simultaneous presence of subjective feelings of tension, apprehension, nervousness and worry (Spielberger & Reiheisser, 2004).

Individuals who are trait anxious are more likely to respond to threats with state anxiety than those who are not (Spielberger, 1972) so that personality influences the likelihood of experiencing anxiety. Effects of personality traits on immediate emotional state are in part mediated by individual differences in styles of appraisal and coping strategies. For example, a trait anxious operator might appraise the enemy as especially threatening, and appraise him/herself as unable to respond effectively, generating state anxiety.

Feelings of anxiety are likely in situations featuring real or perceived performance evaluation, as well as in those characterized by direct threat. Research on the detrimental influence of anxiety on cognitive performance has attributed the effect to preoccupation with task-irrelevant external or internal thoughts, with the latter typically related to personal worries (Calvo & Cano-Vindel, 1997; Sarason et al., 1990). These preoccupations burden central executive function, producing decrements in processing efficiency which, with increases in stress, will translate into decrements in performance (Calvo & Cano-Vindel, 1997; Sarason et al., 1990). Current research has confirmed that anxiety does affect central executive function but, specifically, it biases the inhibition and shifting stages of attentional processing (Eysenck, Derakhshan, Santos, & Calvo, 2007). High levels of state anxiety may therefore lead to declines in performance in task environments requiring frequent attentional shifts, for example during search or detection tasks, or those that present much irrelevant and potentially distracting information.

The current study examines how task load, stress and anxiety influence performance in an ABM environment. Complex tasks such as air battle management require substantial attentional resources, which are needed to implement executive processing (Wickens, 1991). Insufficient resources and attentional failures can cause performance errors. Distraction may arise from the visual load in monitoring tasks (St. John, Manes, Smallman, Feher, & Morrison, 2005), or may be due to the impact of anxiety on attentional control (Eysenck at al., 2007). Therefore, in order to prevent operator errors, an understanding of the impact of stress and anxiety on attention is necessary. Next, the attentional processes that may be critical for effective ABM performance are discussed. After discussing attentional mechanisms, including those for change blindness, the potential impact of anxiety on attention will be discussed in greater depth.

Attention

Human experience arises from the grouping of many perceptual processes. Whether we are passively viewing a scene or engaging in a command and control task, our perceptual systems are constantly bombarded by stimuli. Attention is not an array that is directed towards multiple stimuli simultaneously but is instead like a spotlight that can be directed to specific parts of a scene to enhance information processing (Posner, 1980; Posner, Snyder, & Davidson, 1980). Though attending to a memory or visual object seems instantaneous it is more complex. First attention is internally or externally cued or oriented to a stimulus, followed by conscious awareness of the stimulus (i.e., *detection*; Posner, 1980), a process distinct from orientation. This differentiation clarifies why directing the fovea to a stimulus does not guarantee detection.

Posner and Petersen (1990) describe overt orienting of attention, disengagement, and general shifting as categories of visual attention. These functions have been localized to specific brain regions by neuroimaging studies of attention in monkeys and humans, and also in functional studies of individuals with cortical damage (Posner & Petersen, 1990). Though this model is specific to visual attention, neurocognitive models of attention posit that these processes are correlated with general attention and working memory (Awh & Jonides, 2001). The capacity to control attentional focus is frequently referred to as *executive processes*, which are believed to be similar to the central executive described in Baddeley and Hitch’s (1974) model of working memory. Research suggests that these executive processes are localized to the prefrontal cortex (PFC; Jonides, Lacey & Nee, 2005; Fletcher & Henson, 2001).

Studies of the PFC and observations of patients with damage to the frontal lobes show that executive functioning can be broken down into several sub-processes. Through confirmatory factor analysis, Miyake et al. (2000) have identified three types of executive function: shifting, updating, and inhibition. The shifting function has also been referred to as “task switching” or “attention switching,” which requires disengagement from a current task in order to engage a new task or mental set. In the context of ABM operations, task switching is necessary to not only view multiple screens, viewing back and forth between them, but also to switch attention from internal processes such as processing communication from teammates. This function is further complicated by the need to fight proactive interference from the previous task, and has been shown to have predictable associated temporal costs (Miyake et al., 2000). Updating also involves monitoring and coding of information that is relevant and necessary for performing a task. This activity was measured by Miyake et al. (2000) with tracking tasks, a letter memory task, and tone monitoring, all of which required a periodic check of incoming information with information held in working memory. In the context of ABM, this activity could occur as new aircraft appear on an operator’s display; the operator would first direct attention to necessary entities and then perform updating by encoding an amity label and/or directional information for the new aircraft. Lastly, inhibition is described as the ability to inhibit “prepotent responses” as is done when performing the Stroop task or anti-saccade task (Miyake et al., 2000). The Stroop task (Stroop, 1953) requires participants to verbalize visually presented words. The task becomes more difficult if the words and their associated ink colors are incongruent (e.g., the word “red” is presented in blue ink), which requires participants to inhibit the ink color information. Similarly, the anti-saccade task requires that, when presented a stimulus, participants must inhibit the tendency to orient to presented stimulus, and instead fixate the stimulus’ mirror position

(Everling & Fischer, 1998). In an ABM operation, the prepotent assumption that an aircraft unexpectedly appearing in friendly airspace is not friendly would require inhibition of the related program or script to attack until further evaluation is done.

These attentional stages overlap across simple visual attention and larger executive functions. It is easy to see how change detection might require orienting of attention to a target, disengagement from previous stimuli, and shifting to other areas of the visual scene but it is difficult to build hypotheses of how these stages are affected by internal stimuli. The movement of the attentional spotlight between internal and external stimuli might be better understood through the stages of executive function presented by Miyake et al. (2000). It is at these stages that performance on complex tasks may be impacted both positively and negatively by top-down knowledge.

Change Blindness

In both basic lab studies and naturalistic studies of visual detection, individuals may not notice changes directly in front of them, a phenomenon termed *change blindness* (CB). It has previously been defined as the lack of awareness of considerable changes in a visual scene when changes occur simultaneously with visual transients or distractions (e.g., eye movements, Rayner, 1998; screen flashes, Rensink, O'Regan, & Clark, 1997). This curious occurrence has been observed in many experiments featuring a simple switch in view, called a "one-shot" paradigm, between a pre-change and post-change image (Rensink et al., 1997; Rensink, 2002). Images in these experiments were separated by an inter-stimulus interval (ISI) of 80 ms to reduce the apparency of motion transients associated with the change. Surprisingly, change blindness may also occur during active search due to saccadic suppression or eye blinks (Rensink et al., 1997; Rensink, 2000; Rensink, 2002). To manipulate ISI and allow for voluntary visual search, the “flicker task” was developed, which alternates presentation of pre-change and post-change stimuli, separated temporally by a visual mask. The flicker task provided evidence for Rensink and colleagues’ (1997) explanation of change blindness: attention is needed to observe change; otherwise, visual memory replaces or “overwrites” the pre-change image with a memory of the post-change image.

While the change blindness effect generalizes to naturalistic scenes (Simons & Rensink, 2005), the previous explanation did not. An alternate explanation, which has received substantial empirical support, posits that change blindness results from an observer’s failure to compare internal representations of pre- and post-change scenes (Simons, 1996; Henderson & Hollingsworth, 1999; Mitroff, Simons, & Levin, 2004). Many task variations have been conducted, but the format of studies examining this hypothesis has remained roughly the same. An experimenter approaches a would-be participant and asks for directions. During this exchange, confederates walk between the experimenter and the participant, obscuring the participant’s view, and in so doing serve the same role as the distracter or visual mask utilized in laboratory studies (O’Regan, Rensink, & Clark, 1999; Simons & Rensink, 2005). During this distraction period, the confederates also change some aspect of the situation (e.g., they replace part of the experimenter’s dress, an object being carried by the experimenter, or the experimenter entirely; Simons, 1996; Simons, Chabris, Schnur, & Levin, 2002). In these studies, post-experimental questioning reveal that participants were frequently unaware of changes, but were able to correctly identify pre-change objects, even when they were atypical (e.g., a red and white striped basketball as opposed to the prototypical orange; Simons, 1996).

The difference in theoretical explanation for change blindness can be reconciled by the unifying proposition that attention is necessary to detect change. Evidence of the need for focused attention comes from speeded detection of changes in objects of central interest as opposed to those of marginal interest (Rensink et. al, 1997; Simons & Rensink, 2005). In the absence of focused attention, implicit detection may occur without attention creating a mental representation of the change object (Beck & Levin, 2003). This process may occur without conscious awareness of change detection, and may be facilitated by higher-level knowledge (Rensink, 2000). Top-down knowledge may prime attention to a few related feature detectors during the initial scan of a visual scene. An example of this process is shown in Figure 1 (Treisman, 2006). Conscious detection may be facilitated when the top-down knowledge guiding attention is well-accessed, or has lower thresholds for activation according to connectionist models of processing. When information stored in long term memory primes processing of specific feature detectors, the presence of many related features causes complete access to the related information in long term memory. This view is supported by research suggesting that personal relatedness and expert knowledge improve detection in naturalistic studies (Werner & Thies, 2000). For example, using the previously described “experimenter solicits a bystander for directions” task, Simons and Levin (1998) found that when the pre-change experimenter is identified by the participant as belonging to the same social class, the absence of the experimenter was more likely to be detected (Simons & Levin, 1998; Rensink, 2000).

Similarly, expert knowledge in a domain provides more efficient scanning of scenes (Rensink, 2000; Rensink, 2002). For example, Werner and Thies (2000) manipulated the semantic relatedness of changes in football-related scenes and tested change detection performance of domain experts and novices. Change detection was significantly higher for experts when the change altered the semantic meaning of the football scene. While attention is only necessary for conscious detection, it seems attention can be easily facilitated to improve performance.

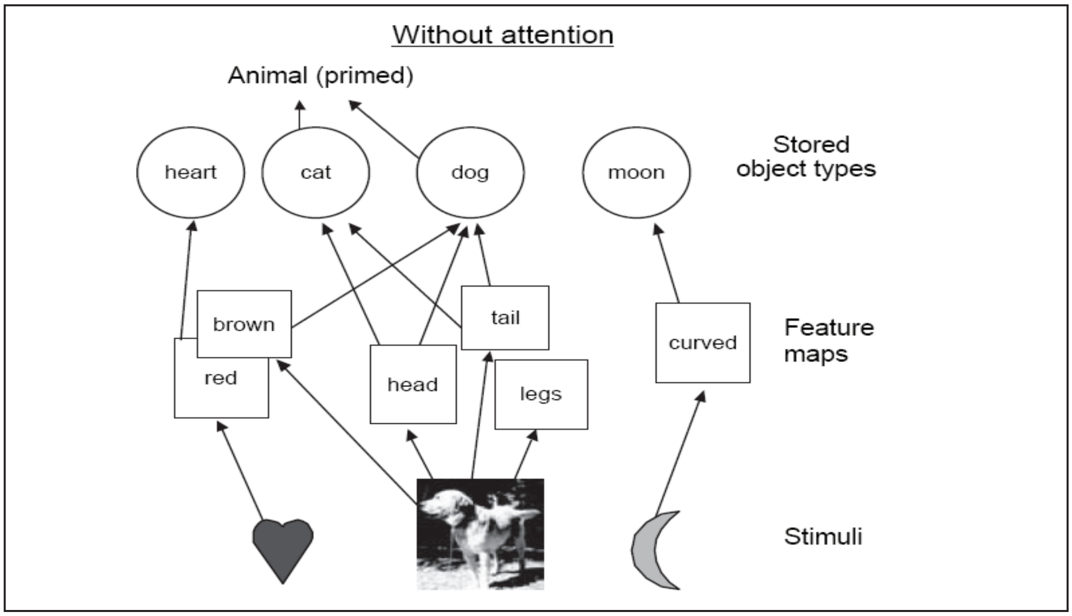

Figure 1. Treisman's (2006) model accounting for detection under situations of divided attention. In the model presented, a letter discrimination task is being carried out simultaneously with an animal identification task. Treisman posits that in the first visual scan, features associated with "animals" are primed and may fire if enough of those features are present. Adapted from "How the Deployment of Attention Determines What We See" by A. Treisman, 2006, *Visual Cognition*, *14),* p 440. Copyright 2006 by Psychology Press Ltd.

The relationship between attention and change detection is of great interest in military contexts. The Army, Navy, and Air Force operational environments require C2 operators to monitor informative, but frequently cluttered, tactical displays to receive and share critical mission-related information (St. John et al., 2005; Knott, Funke, Knott, Miller, & Panganiban, 2010; Durlach, 2004). In these environments, detection errors are quite likely due to the high attentional and temporal demands placed on operators (Durlach, 2004). For example, in an army battle simulation, participant change detection decreased nearly 40% when changes occurred simultaneously with the closing of a task window that briefly obscured the primary tactical display (Durlach, 2004).

Another means of studying change blindness in the military domain is to focus on task factors that may facilitate change detection. Tollner-Burngasser, Riley, and Nelson (2010) studied change blindness in a team C2 setting. The stimuli employed by Tollner-Burngasser and colleagues (2010) were static displays of red, green, and blue squares. Participants were required to monitor flicker sequences of displays containing 6, 12, 24, or 48 icons for small or large changes in icon position. Though change blindness did occur, results of the study revealed that teams that communicated with one another while searching for a change showed fewer errors and higher detection rates than non-communicating teams. This effect was greatest with small icon position changes. Additionally, as set-size increased, performance decreased, indicating that the task imposed a burden on attentional processes.

Knott et al. (2010) further investigated the role of mental demand and teamwork in a C2 task requiring change detection. Teams participated in either dual task or single task conditions. In the dual task condition, teams played the role of air battle managers whose primary task was to direct a team of confederates in a simulated air defense task. The secondary task, which was embedded within the air defense task, required participants to detect the change of unknown aircraft icons into to either neutral or enemy aircraft. In the single task condition, participants viewed video recordings of the dual task air battle simulation and performed only the change detection task. Though dual task teams performed the change detection task more poorly than single task teams, they seemed to benefit from both the semantic relatedness and practice, in that participants exhibited faster reaction times to hostile than neutral target changes and, overall, detection speed increased across experimental sessions. This extension of the principles of change detection into a military simulation illustrates how additional factors inherent in C2 tasks may influence change detection, but more importantly, provide insight into ways to protect against change blindness.

Anxiety and Attentional Processes

A cognitive approach to anxiety allows one to identify cognitive processes associated with anxiety and observe their impact on attention and performance (Sarason et al., 1990). Trait anxious individuals are believed to be pre-occupied with the potential for danger or harm. The processing efficiency theory (PET; Eysenck & Calvo, 1992; Eysenck et al., 2007) posits that anxiety's effects on performance are due to task-irrelevant, usually self-defeating, thoughts which interfere with cognition (Sarason et al., 1990). According to PET (Eysenck & Calvo, 1992), worry-related thoughts affect central executive functioning by interfering with processing and storing of task-relevant information. Worry is believed to affect the efficiency of performance, forcing anxious individuals to compensate for processing inefficiencies with increased effort. The negative effects of worry on performance are most frequently observed during performance of highly demanding tasks; easy tasks may allow sufficient spare mental resources to successfully offset worry's effects.

Based on assumptions from PET (Eysenck & Calvo, 1992), attentional control theory (ACT; Eysenck et al., 2007) attributes anxiety's impact on executive functioning to specific attentional processes. Following Miyake and colleagues' (2000) model of executive function, ACT proposes that anxiety affects performance by upsetting the balance between two attentional aspects of executive function: the goal-directed and stimulus-driven attentional systems. Anxiety affects the inhibition stage by allowing automatic processing of threat-related stimuli and by lowering related activation thresholds. Control by the goal-directed system decreases due to task-irrelevant, salient stimuli seizing attention. Perceived threats cause a shift from goal-directed attentional strategies to less effective strategies that include monitoring threat sources, requiring additional effort and expenditure of attentional resources. The process further hinders executive functioning by weakening control of attentional shifts and preventing engagement of task-relevant stimuli. The process described by ACT was observed in a change detection study utilizing snake-fearful and snake-tolerant participants (McGlynn, Wheeler, Wilamowska, & Katz, 2008). Using a flicker task, participants were asked to detect a change superimposed on a background image which either did or did not include the image of a snake. The study results included an interaction between groups and stimuli, revealing that snake-fearful individuals required more alternations between images in order to detect a change. McGlynn and colleagues (2008) interpreted this as an inefficiency of processing caused by difficulty disengaging attention from the snake images.

Research on anxiety has also revealed a bias in selective attention to threat-related information, resulting in a lowered threshold for retention and retrieval of threat-related information. This finding has been consistently reproduced across many experimental paradigms (see Bar-Haim et al., 2007, for an extensive review and meta-analysis). For example, the emotional Stroop task (EST) reveals greater interference for threat and negative affect terms in anxiety patients attributed to automaticity in recognition of these terms (MacLeod & MacDonald, 2000). Extension of these findings to non-clinical populations is somewhat unclear. Some research (e.g., Rutherford, MacLeod, & Campbell, 2004) suggests that selective attention to negative terms occurs as a result of an interaction between state anxiety and trait anxiety. Rutherford et al. (2004) administered the EST to low and high trait anxious students during periods with and without evaluative aspects (during exams and before classes, respectively).

State anxious scores measured using the State-Trait Anxiety Inventory (STAI; Spielberger, Gorusch, Lushene, Vagg, & Jacobs, 1983) increased in the high condition. The EST revealed that the high state anxiety condition elicited slower color-name reaction times such that low trait-state anxious individuals were sensitive to general emotional stimuli, while high trait anxious individuals showed bias to specifically negative stimuli. Such findings promote investigation of the interactions between state and trait anxiety in non-clinical populations.

Thus, studies of selective attention and cognitive interference indicate that trait anxiety may have both direct and indirect effects on performance. The state-trait model of anxiety (Spielberger, 1972) indicates that high trait anxious individuals are more likely to become state anxious and to experience more intense state anxiety than others, and so are more vulnerable to the general attentional impairments described by PET (Eysenck & Calvo, 1992) and ACT (Eysenck et al., 2007). In this case, the effect of the trait on attention is indirect, in that it is mediated by state anxiety (or worry). However, studies of attentional bias suggest that state anxiety may not be sufficient for selective attention to favor threat stimuli. High trait anxiety is also necessary, implying that there are stable individual differences in threat processing associated with the trait. The selective attention bias reviewed by Bar-Haim and colleagues (2007) seems to reflect a direct influence of trait anxiety on attention in different experimental paradigms, in both clinical populations and individuals scoring high on a measure of trait anxiety. Thus, to understand the impact of anxiety in an ABM context, it may be necessary to differentiate the stable personality traits of the operators, and the immediate anxiety state.

In summary, anxiety should be regarded as an emotional state that is experienced more often and at greater intensity by individuals with trait anxiety. In operational settings, sources of threat may be internally driven, such as knowledge of the consequence of poor performance, or externally driven, detection of an approaching enemy target. Individuals with trait anxiety have lowered activation levels for both bottom-up processing and top-down processing of threat related stimuli; threatening stimuli in the environment may be automatically processed while threat related concepts in long term memory are automatically activated. This difference in threat processing directly impacts the executive function of attentional control as posited by ACT (Eysenck et al., 2007). Thus, anxiety may be related to multiple attentional vulnerabilities. Trait anxiety may be associated with a selective attentional bias towards threat, perhaps accentuated by state anxiety (Rutherford et al., 2004). Weak executive control over such biases (Eysenck et al., 2007) may leave the operator prone to fixate on the highest-priority threats, while neglecting other areas of the visual field. State anxiety and worry appear to elicit more general attentional deficits, expressed as disruption of executive functioning and lack of attentional resources. Such deficits may also lead to change blindness, to the extent that this phenomenon reflects suboptimal executive control of scanning of the visual field. Attentional impairments are likely to be especially detrimental when the battle space is complex, so that the operator must keep track of multiple friendly and enemy units.

The studies reviewed also suggest some scope for anxiety to have beneficial, or at least mixed, effects on attention. PET (Eysenck & Calvo, 1992) emphasizes that anxious individuals often apply compensatory effort to overcome distraction. The literature on selective attention bias suggests that anxious individuals may be less likely to ignore threats than those low in anxiety. Thus, biases in performance and attention as posited by PET (Eysenck & Calvo, 1992) and ACT (Eysenck et al., 2007) may vary across tasks and individuals.

Effects of Stress and Anxiety on Change Blindness Susceptibility in C2

The current study is an exploration of the impact of anxiety on cognitive processing in an air defense task. A brief search of the literature suggests that this is the first experimental attempt at investigating how anxiety might impact attention during C2 operations. The study of the impact of trait and state anxiety in real world applications in general is limited, and the C2 environment has various features that may not be reproduced in typical laboratory studies of anxiety and information. Three such features are the use of complex, multi-element displays, multifaceted stress responses associated with multiple motivations, and the need to perform in teams.

Tactical displays showing the battle space are typically complex, requiring the operator to search for relevant items of information. As proposed by ACT (Eysenck et al., 2007), anxiety may impair the goal-directing system of attention which could cause difficulties with switching focused attention across multiple displays. However, according to PET (Eysenck & Calvo, 1992) anxious operators may exert added effort to make up for the inefficiency of attentional processing. Few laboratory studies have tested the effects of anxiety in real world settings. Consistent with the PET (Eysenck & Calvo, 1992) account of anxiety, a recent study of decision-making found that, under some circumstances, state anxiety related to a higher frequency of observations of a map display (Matthews, Panganiban, & Hudlicka, 2010). Yet, this study also found that high trait anxious subjects were especially prone to acquire information about potential threats, consistent with the account of anxiety showing a bias of selective attention to threat-related items (Eysenck et al., 2007, Bar-Haim et al., 2007). Matthews et al. (2010) indicated that the findings from this applied study of anxiety and performance indicate that the effects of anxiety can vary across measures of performance and sources of threat.

Another critical issue for C2, as mentioned previously, is that operators may experience a variety of stress responses. Broadly, military C2 personnel are exposed to stressful, high-workload events, which may make them more vulnerable to anxiety and stress. However, task demands may be perceived as challenging or threatening depending on the individual's appraisal of the situation (Lazarus, 1993), so that a range of emotional responses are possible. The context is also likely to be highly motivating, and interaction with team members may activate further goals, such as maintaining team morale. It follows that evaluating only 'stress' or 'anxiety' will be insufficient to provide an adequate assessment of operator mental state.

Matthews and colleagues (2002) have proposed that a multivariate approach to assessment of subjective states in stressful performance environments is necessary, including measurement of motivational and cognitive states, as well as emotions. The Dundee Stress State Questionnaire (DSSQ: Matthews et al., 2002) is a validated multidimensional measure of stress that provides deeper insight into stress in performance settings. Based on pre-task and post-task comparison, three broad factors of engagement, distress and worry can be measured (Matthews et al., 2002), affording a detailed quantitative assessment of changes in subjective state induced by task demands and extraneous stressors such as loud noise. Specifically, task engagement provides insight into the operator's level of energy, motivation and concentration. It fluctuates based on effort; task engagement drops in monotonous tasks that place high demand on sustained attention. Distress relates to an attempt to a struggle to maintain performance, and use of emotion focused-coping to deal with overload. It is highly correlated with the NASA Task Load Index of workload (NASA TLX: Hart & Staveland, 1988; Matthews et al., 2002). Worry relates to self-referent thoughts and an internal, personal focus on attention. These factors may prove successful indicators of stress response in highly demanding settings such as ABM due to their sensitivity to cognitive task demands, and relationships to personality factors such as anxiety and neuroticism (Matthews & Campbell, 2010). ABM settings place high demands on working memory (WM) and may elicit substantial distress responses similar to those obtained for WM tasks by Matthews and Campbell (2010).

Another characteristic source of stress in ABM may be derived from teamwork. Guznov, Matthews and Warm (2010) found that teams performing a computer-based 'capture the flag' task reported higher levels of engagement, as measured by the DSSQ (Matthews et al., 2002), than individuals working alone but also higher levels of workload as measured by the NASA TLX. This finding indicates a cost to teamwork, which may come from the effort of coordination and communication. Guznov et al. (2010) also indicated that some personalities may be less equipped to deal with the stress of teamwork; neurotic individuals appeared to be more sensitive to distress in team member roles which require direct control of operations. Given findings for neuroticism to be positively correlated with anxiety (Matthews & Deary, 1998), neuroticism may have made team members sensitive to evaluative anxiety arising from the social context. Under this assumption, differing levels of trait anxiety across team members may interact with task demands to influence state anxiety and reveal performance decrements predicted by PET (Eysenck & Calvo, 1992) or by ACT (Eysenck et al., 2007).

Experimental Goals and Hypotheses

The current study aims to observe the impact of anxiety on change detection in two-person teams performing a simulated ABM task. Participants were required to work in teams because teamwork is an inherent aspect of ABM operations and previous work examining change detection in ABM (Tollner et al. 2010; Knott et al., 2010) found that team communication improved change detection. The task required participants to use fighter aircraft under their control to destroy incoming enemy planes (offense), and to protect their own assets, including aircraft and civilian camps below the battlespace (defense). The study aimed to distinguish the impacts of trait and state anxiety on detection of target aircraft differing in level of threat. The study also aimed to test the role of anxiety extraneous to immediate task demands, produced by a mood induction validated in the performance context by Matthews et al. (2010). Subjects were pre-screened for inclusion based on low and high trait anxiety, so that teams of high, mixed and low trait anxiety might be compared. All teams performed the task in both neutral and anxious mood inductions.

Similarly to Matthews et al. (2010), the mood induction was hypothesized to successfully elevate reported anxiety following the anxious mood induction and the ABM performance block that followed the induction (H1). The Spielberger (1972) theory predicts that the anxiety response should be enhanced by higher levels of trait anxiety (H2). States were assessed more broadly using the DSSQ. As state anxiety measured by the STPI correlates with both the distress and worry dimensions of the DSSQ (Matthews & Campbell, 2010), increases in state anxiety should be accompanied by elevated distress and worry (H3). Distress and anxiety might also be elicited by the workload of the task, including the demands of teamwork (Guznov et al, 2010). According to PET (Eysenck & Calvo, 1992), anxious individuals experience higher cognitive workload in stressful environments, because they must direct effort towards resisting distraction. Thus, it was expected that high anxious teams should report higher levels of workload than mixed anxious and low anxious teams (H4).

The impact of anxiety on attention was anticipated to affect both overall performance, assessed as separate offensive and defensive scores, and change blindness in relation to incoming aircraft. Failures of attention have previously been indicated as influencing change blindness

(CB: Rensink, 1997; Simons & Rensink, 2005). Change blindness was assessed by requiring the participants to respond when an icon representing an unknown aircraft changed to an icon representing one of several known icons. Identity of the change was believed to influence CB based on the finding that task-relevance improved change detection in a dual task CB and ABM task (Knott et al., 2010). Therefore, the current study manipulated the threat level of icons as neutral (no threat), low-threat, or high-threat). It was anticipated that fewer changes to neutral icons would be detected across all teams, as found in Knott et al. (2010), as well as slower reaction times to changes in neutral icons (H5). Also anxiety should interact with threat level in its effects on change detection performance. If anxiety hinders the attentional control system via automatic processing of threat and difficulties with the disengagement of attention, CB should be higher in high anxious teams (H6), as revealed in higher counts of CB and slower reaction times. Offensive and defensive performance is anticipated to reflect demands on attentional resources. Performance of the ABM task is expected to decline when state anxiety is induced (H7) due to the impact of anxiety on resources. The relationships between anxiety and performance specified by H6 and H7 were also tested by calculating correlations between state measures and performance indices, in addition to testing effects of the anxiety manipulation.

Method

Participants

Forty-six individuals (15 women, 31 men, M_{age}= 21.22 years, age range: 18-29 years) were recruited for this study from the Wright-Patterson Air Force Base (WPAFB) subject pool. The WPAFB subject pool consists of individuals between 18-30 years of age, who are US citizens, have at least some college experience, and have normal (20/20) or corrected-to-normal vision. Recruitment flyers for the subject pool were placed at local Dayton Universities, the University of Cincinnati and on www.craigslist.com (Appendix A).

Participants were screened for eligibility based on their scores of trait anxiety from the State-Trait Personality Inventory (STPI; Spielberger et al, 1979) and their responses to an emotional health questionnaire (described below). Individuals with STPI scores outside the range of 0.5 standard deviations above and below the normative mean for trait anxiety (i.e., scores less than 16.32 and greater than 21.42) were included in the study. For the purposes of this study, these scores were used to categorize each participant's level of trait anxiety (low or high) and to place them into one of three trait groups: low anxious group (n = 9); mixed anxious group (n = 7); high anxious group (n = 7). Low anxious and high anxious groups were comprised of low and high trait anxious members, respectively, while mixed anxious groups had both low trait and high trait members.

Experimental Design

This experiment utilized a 3 × 3 × 2 × 2 mixed design. The between-groups factor was team composition (low anxious; mixed anxious; high anxious). Within-groups factors included trial mood state (Neutral-1/Anxious/Neutral-2) and target amity (neutral, low-threat, high-threat).

The dependent measures collected in this experiment included measures of offensive and defensive performance in the air battle management task, measures of change detection, and several subjective state measures.

Materials

Emotional Health Questionnaire. The questionnaire was used to exclude potential participants who may have been emotionally vulnerable to the experimental manipulations and consisted of three items (Appendix B). Participants who reported that they had been diagnosed or treated for any of the mood-related disorders (i.e., Bipolar I and II Disorder, Panic Disorder, Phobias, Acute Stress Disorder, or Generalized Anxiety Disorder) listed in the DSM-IV (American Psychiatric Association [*DSM-IV-TR*], 2000) were excluded from the study.

State-Trait Anxiety Assessment. The STPI (Spielberger, 1996) is an 80-item, untimed, and self-administered survey used to assess emotional states related to anxiety, anger, depression and curiosity. The frequency of these experienced emotions provides a measure of trait while the magnitude of the current experienced emotion is linked to state measures. The STPI was developed using items from the State-Trait Anxiety Inventory (STAI; Spielberger, 1983; Spielberger & Reheiser, 2004) and the State-Trait Anger Expression Inventory (STAXI; Spielberger, 1988; Spielberger & Reheiser, 2004), as well as additional items addressing depression and curiosity. In the current study, participants completed items related to the anxiety and anger subscales of the STPI (20 items total, see Appendix C for a list of the items). Instructions for the trait version of the STPI request that responses to items be based on *general* feelings. In contrast, the state version requires that participants respond based on the intensity of their feelings as they are *at the moment.*

The STAI was constructed with adapted items from other anxiety measures. Concurrent validity of the items was assessed by their correlation with the Manifest Anxiety Scale (Taylor, 1953; Spielberger & Reheisser, 2004) and the IPAT Anxiety Scale (Cattell & Scheier, 1963; Spielberger & Reheisser, 2004). Test-retest stability coefficients ranged from .73 to .86 over 20 to 104 days for the Trait scale. The nature of the State scale should not provide high test-retest reliability. Therefore, measures of internal consistency were obtained from a sample of high school and college students, working adults, and military recruits for both the state and trait scales, revealing alpha coefficients with a median of .93 and .90, respectively.

The STAXI was derived from the combination of the 20-item state-trait anger scale (STAS S-Anger and T-Anger; Spielberger, 1980; Spielberger & Reiheisser, 2004) and the 24-item Anger expression scale (AX; Spielberger, Krasner, & Solomon, 1988; Spielberger & Reiheisser, 2004). The STAS S-Anger and T-anger scales were administered to a sample of university students and showed internal consistency (alpha coefficients for S-Anger and T-Anger were .93 and .87 respectively). Test-retest reliability coefficients were .70 over a two week period. Administration of the STAS T-anger scale, Buss-Durkee Hostility Inventory (Buss & Durkee, 1957; Spielberger & Reheisser, 2004), the Hostility scale (Cook & Medley, 1954; Spielberger & Reheisser, 2004) and the Overt Hostility scale (Schultz, 1954; Spielberger & Reheisser, 2004) to college students and navy demonstrated that the STAS possesses good convergent validity (r =.63).

Mood Induction. The technique created and validated by Mayer, Allen, and Beauregard (1995) was administered using PowerPoint on a computer. The technique is a mix of guided imagery and music. Participants were instructed to try to place themselves in the described mood. They were told that they would hear music for one minute before being presented with a series of vignettes. They were instructed to read the vignettes and imagine that they were in the described situations. After the Instruction slide a blank slide appeared. Participants were then presented with appropriately themed music for one minute through a pair of Sennheisser Noise Reduction headphones. Mood related vignettes were then presented at a rate of one every 30 seconds; each vignette was presented for a total of two minutes, after which a new vignette slide appeared. In total, participants were presented with eight such vignettes. The mood induction was employed at the beginning of each trial block to elicit either an anxious or neutral mood. Anxious mood materials were adapted from Mayer et al. (1995) and the neutral materials were adapted from Marzillier and Davey (2005; see Appendix F for a complete list of music and vignettes). Music from the induction was continued throughout the experimental block with an additional anxious or neutral song adopted from Shapiro and Lim (1989: Appendix F). Following completion of the experiment, a *happy* mood induction, adapted from Mayer et al. (1995), was offered to participants to neutralize any remaining negative affect.

Workload. The NASA-Task Load Index (TLX; Hart & Staveland, 1988; Appendix E) was administered to obtain subjective measures of workload from the participants. The NASA-TLX features six subscale dimensions, including mental demand, physical demand, temporal demand, performance, effort, and frustration. Each dimension is rated on a scale ranging from 0-100. All scales are rated "low" to "high," except performance, which is rated from "good" to "poor." The NASA-TLX has a reliability of $r = .83$ (Hart & Staveland, 1988), and is a commonly used measure of subjective workload in the human factors field (Wickens & Hollands, 2000).

Subjective Stress State. A short version of the Dundee Stress State Questionnaire (DSSQ; Matthews, Emo, & Funke, 2005; Appendix D) was administered during the experiment to assess the three broad state factors identified by Matthews et al. (2002). The pre-task version of the DSSQ was given at the beginning of the study and the post-task version of the DSSQ was given at the end of each of the three trial blocks to detect changes in three state factors: task engagement, worry, and distress. Task engagement reflects participants' task-related motivation, and includes items like "I am/was determined to succeed on the task." Worry reflects task-irrelevant and negative self-referent thoughts (i.e., "I am/was worried about what other people will think of me). Distress is reflective of negative emotions, and lack of perceived control over the demands of the task (i.e., "I felt like I can/could handle any difficulties I encountered").

Apparatus

Participants were seated approximately 24 inches from a Windows PC with a 19 inch computer monitor. Surveys, computer based training (CBT) and mood inductions were administered using the experimental computer. Team members communicated with each other using the Sennheisser microphone headsets described previously. Task-related sounds (described below) were also played over the headphones. Music corresponding to the mood condition for the experimental block was played in the laboratory at 60 dB via computer speaker during each trial. The experimental stations faced opposite sides of the laboratory with an approximate distance of 20 feet between participants, to ensure that participants consistently communicated using the headsets.

The simulated environment utilized in this experiment was Aptima, Inc.'s Distributed Dynamic Decision-making (DDD) software (version 3.0; MacMillan, Entin, Hess, & Paley, 2004). DDD is a tool for creating scriptable, low-to-moderate fidelity, human-in-the-loop multi-participant simulations. It has successfully been used to simulate team command and control tasks, to differentiate between low and moderate task loads, and to study realistic and complex team processes in a variety of military and civilian research projects (MacMillan et al., 2004). The DDD was employed in this experiment to create a set of air defense simulations conveyed to participants through a tactical display.

Air Defense Task. For the air defense task, participants assumed the role of air battle managers. However, unlike real air battle managers, participants in this experiment directly controlled the actions of team assets (as opposed to coordinating mission-related activities within the battlespace).

Figure 2 depicts a screenshot from one participant's tactical display. The objective of the air defense task was to protect both civilians and team assets by attacking enemy aircraft as they moved through the simulated battlespace. Within the simulation, each participant assumed control of four fighter aircraft and an aircraft tanker. These assets allowed participants to patrol and defend simulated civilian camps (represented as human silhouette icons in the scenario) which were stationary and could not be moved by participants. During each trial, enemy, neutral, and “unidentified” aircraft entered the scenario at a rate designed to create a consistent level of task demand throughout the trial.

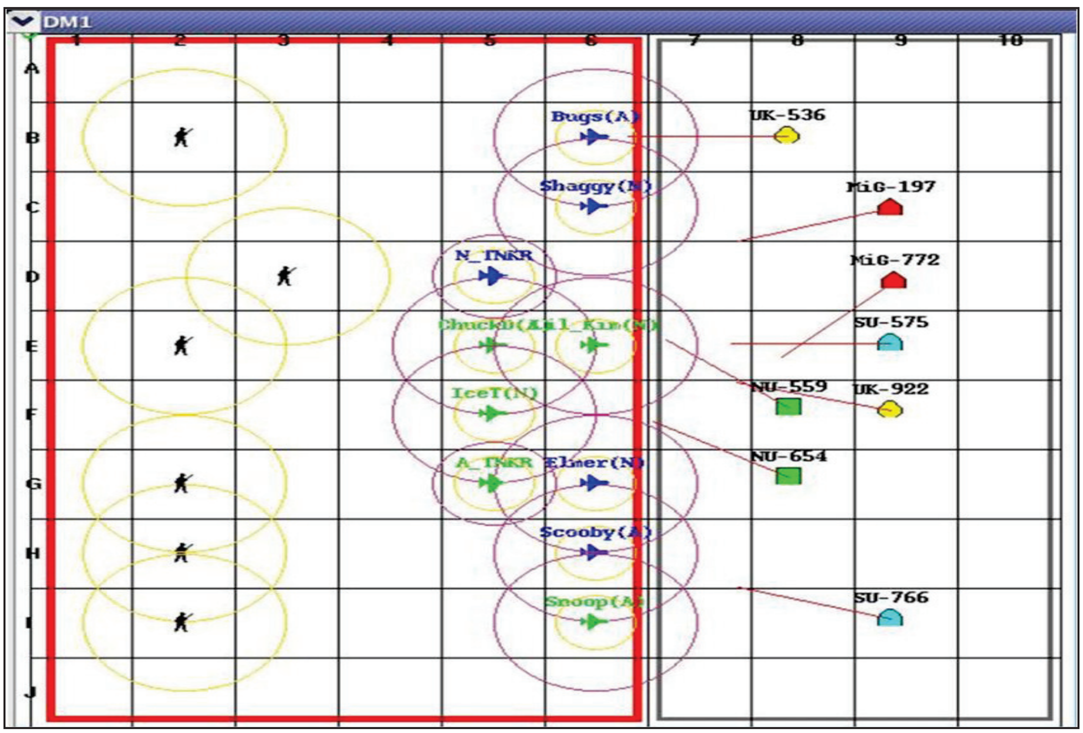

Figure 2. Participant screenshot of the air defense task. Civilian camps were represented by black human silhouette icons enclosed by a yellow circle. Team assets (fighter planes and supply tankers) were programmed to start each experimental trial in a random formation along the red line demarking friendly and enemy airspace. High-threat enemies were aqua, low-threat enemies were red, neutral aircraft were green, and unidentified aircraft were yellow.

The simulated battlespace included two of each of the following aircraft: neutral, low-threat, high-threat, and “unidentified.” Neutral aircraft represented commercial airliners. Low-threat and high-threat aircraft represented enemy fighters (Figure 3). Enemy aircraft differed in their level of threat to participants: low-threat enemies had weapons capable of attacking team assets, while high-threat enemies could attack both team assets and civilians. Unidentified aircraft were described to participants as aircraft that had not yet been identified within the simulation, but which had the possibility of subsequent identification as a neutral, low-threat, or high-threat aircraft. Examples of neutral and enemy icons are depicted in Figure 3. These icons were used in a previous change blindness study (Knott et al., 2009), in which change blindness was studied as a single-task or as part of a dual-task condition similar to the current study. In the dual-task study, participants performed an ABM task while detecting changes in unidentified aircraft to either neutral or enemy targets. Participants in the single-task condition performed at nearly 100 % accuracy, showing no difference in response to either neutral or enemy targets. This finding suggests that the icons have equal salience.

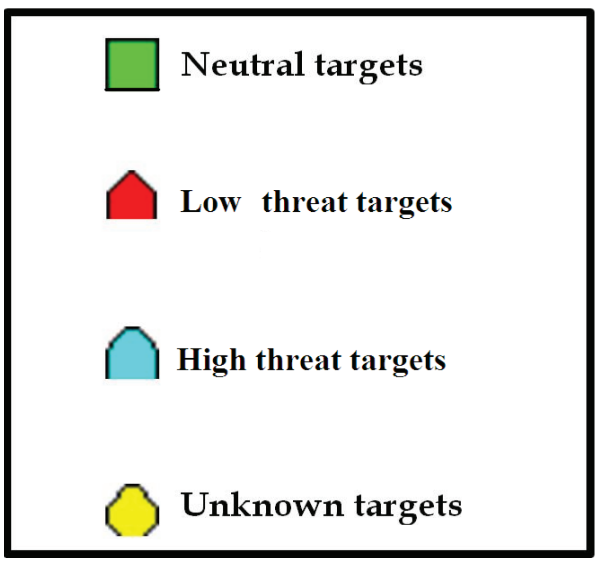

Figure 3. Air battle Management task icons. Icons were adapted from Military Standard 2525B symbols (Department of Defense Interface Standard, 2005).

As mention previously, each participant controlled four simulated aircraft in each trial. Of these, two were armed with weapons capable of attacking low-threat aircraft, and the other two were armed to attack both low- and high-threat aircraft. To encourage participants to work together during the experiment, each controlled tanker aircraft which could resupply half of the teams' assets. Participants were told that team assets were drawn from Air Force and Navy assets (designated in the simulation as "A" or "N" aircraft), and as such, they were required to resupply at the appropriate tanker (i.e., the "A" tanker resupplied "A" aircraft, and the "N" tanker resupplied "N" aircraft). Teams were told their scores (described below) would be penalized if they resupplied assets at the wrong tankers.

Change Detection/Surveillance. Unidentified aircraft were described as planes whose amity had not yet been determined. However, as those aircraft moved through the simulated battlespace, their designation could change to hostile (low- or high-threat enemies) or neutral. Participants were told that these changes represented ongoing automated identifications, and that upon detecting a change in target amity, they should "mark" the change on the screen by clicking on it with the mouse. Each trial included 12 change events (4 low-threat aircraft, 4 high-threat aircraft, and 4 neutral aircraft). Changes occurred at an average rate of one change every 35 s, with a range of 15 to 50 seconds between each event. Reaction time to and detection frequency of change events were measured and factored into the team's score (detailed below).

To create a more standard "flicker" task paradigm, a *verification task* appeared periodically during each trial and served as an occlusion screen (Simons & Rensinck, 2005). Figure 4 shows the progression of one change event from pre- to post-change. Participants were instructed to enter the four digit code they saw on the screen into the adjacent text box. The purpose of this task was to simulate a short distraction that ABM operators may be required to perform during their normal duties, such as sending a short text message, and which may briefly distract them from their tactical displays. The verification task appeared 15 times during each trial and was occasionally followed by a change (60% of the time), ensuring that its appearance did not become a reliable cue for upcoming change events. Each occurrence of the verification task lasted 3 seconds.

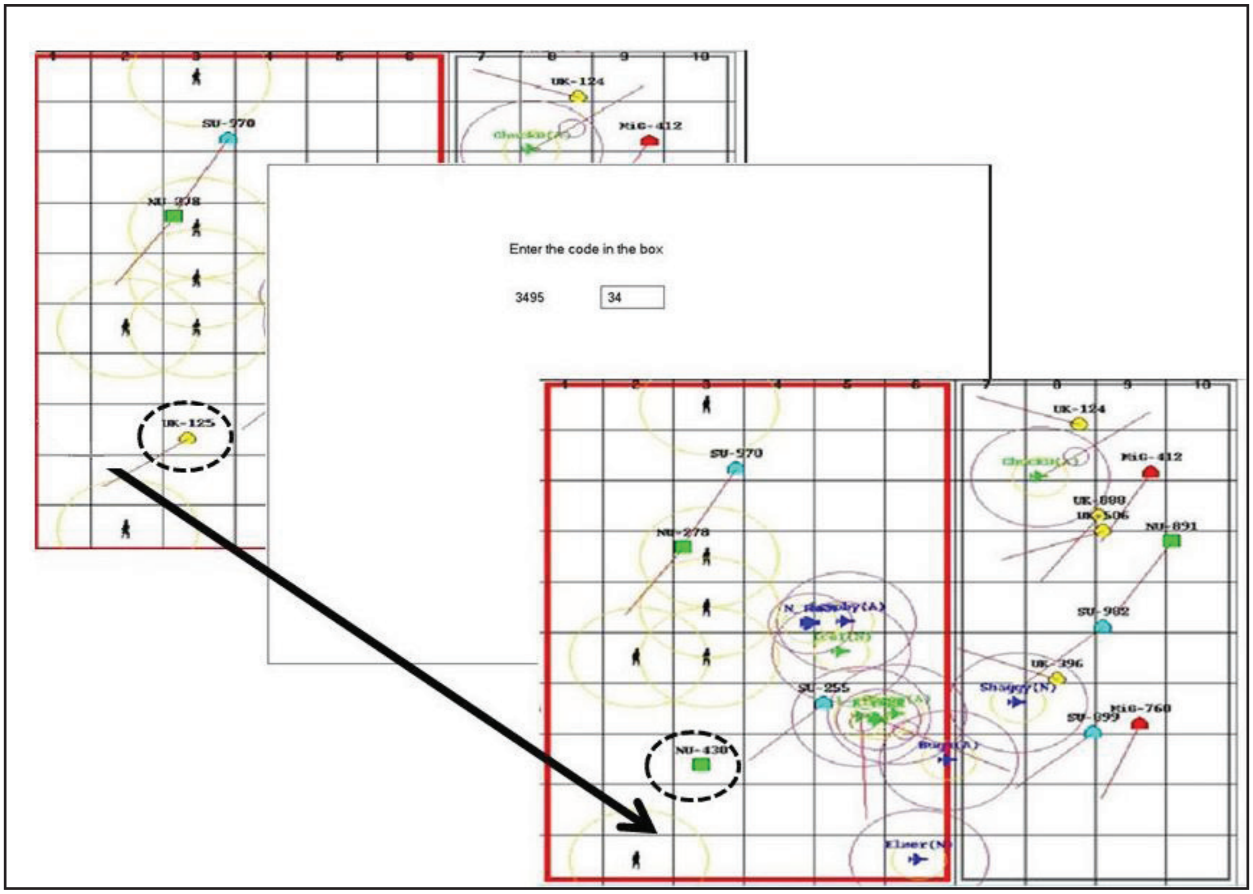

Figure 4. Several screenshots are presented above to provide a depiction of a sequence of task events. In this example, a change event occurs after verification task; changes followed a verification screen 60% of the time. The dotted circle in the figure, which denotes the change of the unidentified aircraft into a neutral aircraft, is presented for illustration purposes only – participants completing the task were not presented with this information.

Additionally, changes varied in detection responsibility, which determined who could observe the changes. One quarter of the change events in each trial were visible to each team member and the remaining changes were visible to both (i.e., of the 12 change events in each trial, three events could only be detected by the first participant, three could be detected by the second participant, and the remaining six could be detected by both participants). This manipulation in visibility required that the team work collaboratively to detect changes and defend the battlespace from enemy aircraft.

Search set size and trial workload were kept relatively constant during the trial by ensuring that the tactical display always included six civilian camps, eight team fighter aircraft, and two team tankers. As previously mentioned, incoming aircraft appeared in waves of eight entities comprised of two low-threat, two high-threat, two neutral, and two unidentified aircraft. To ensure equal representation of all aircraft types, new icons were programmed to replace aircraft that had exited the battle space, changed amity, or been destroyed.

Scoring and Compensation. Participants were paid an hourly rate based on their task performance. Following completion of each experimental trial, participants were provided feedback on their task performance in the form of a "team score." This score reflected how well the team achieved the scenario goals. It was scaled so it could range from 0-100; a score of 0 indicated that the team did not meet any of the goals of the scenario, and a score of 100 indicated that the team met all of the goals perfectly. To encourage participants to engage the ABM and surveillance tasks equally, participants could receive 50 points from each task. Participants earned a maximum of 25 points for offensive performance (number of enemy kills) and retained 25 points for defensive performance (prevention/avoidance of attack on team assets and civilians). Surveillance performance was based on speed and accuracy of the participants' change detections (if both participants responded to a change event, the fastest response received credit). Based on the results of a pilot study, detection reaction times were categorized as fast (under 9 seconds), medium (10-20 seconds) and slow (greater than 20 seconds). Fast marks received 4.17 points, medium marks received 2.08, and slow marks received 1.39. Incorrect marks (marking an object that had not changed) incurred a .5 point penalty. Teams that earned a total of 55 points or higher earned $15 per hour, teams that earned 40-54 points earned $12 per hour, and teams earning 39 points or lower earned $10 per hour.

Procedure

Participants were recruited to work as one member of a two person team. They were matched to a teammate based on their trait anxiety scores on the STPI to create either a low trait anxious/high trait anxious team (mixed anxious), low trait anxious/low trait anxious team (low anxious), or a high trait anxious/high trait anxious team (high anxious). They were told that each of them would play the role of an air battle manager in the simulation. One participant assumed the role of the Blue battle manager, whose assets were represented in the simulation as blue fighter aircraft and the N-tanker, while the second participant played the role of the Green battle manager, who controlled the green fighter aircraft and A-tanker. Team roles were assigned at random. Upon arrival participants were administered baseline surveys of state anxiety and subjective stress state using the STPI and DSSQ.

Training. Prior to experimental data collection, participants completed 2 hours of task training, which involved three modules of computer based training and four practice trials. The three computer based training (CBT) modules were presented in PowerPoint. The first CBT provided basic information on the context of the simulation as well as instructions on how to control team assets. During the first practice trial an experimenter sat beside each participant with a checklist of controls presented in the first CBT. Participants played a 15 minute trial, carrying out the ABM task while the experimenter "checked off" each mastered skill (i.e., moving planes, attacking enemies, and resupplying). The second CBT explained the surveillance task and was followed by a 12 minute trial in which the participants were instructed to try to identify 10 change events. An experimenter sat beside each participant to point out any unnoticed changes and to ask the participant to practice marking detected events. The last CBT explained the verification task and how team performance would be scored. After a third practice trial, participants completed the TLX for the first time. After completing the TLX, scores for the trial were displayed to explain how team scores were calculated and to provide performance feedback. Participants then watched a six minute video clip of a trial performed by an expert team in order to help improve their understanding of the task. Finally, the team was given five minutes to discuss strategy and ways to improve their scores before carrying out their final practice trial.

Experimental trials. The experiment was divided into three trial blocks, differentiated by mood conditions; each block was comprised of three 12-minute trials (yielding a total of 9 trials in each experimental session). The order of mood condition presentation (i.e., trial blocks) was always Neutral-Anxious-Neutral across all teams to counteract any preexisting mood prior to exposure to the Anxious mood condition. Before each block, the corresponding mood induction was administered, followed by an STPI state questionnaire. Music from the mood induction, along with additional music used for neutral and anxious moods (Shapiro & Lim, 1989) played on a loop via computer speakers. The post-test DSSQ and STPI-state questionnaire were administered at the end of each trial block; participants completed the TLX following completion of each experimental trial.

Results

All data was screened for outliers by examination of standardized scores; *z*-scores exceeding 3.3 in absolute value were considered extreme cases (Tabachnick & Fidell, 2001) and corrected by Winsorization. Skewness and kurtosis were assessed for all data prior to analysis and datasets with values above 2 in absolute value were log transformed. In all reported analyses involving repeated measures with more than two levels of the factor, the Greenhouse-Geisser epsilon was employed to correct for violations of the sphericity assumption. To reduce inflation of the Type I error rate, Bonferroni corrections were applied to all post hoc analyses.

State Anxiety

STPI state anxiety measures were obtained upon arrival (baseline), immediately after each mood induction (Neutral-1, Anxious, Neutral-2), and at the end of each trial mood block (Neutral-1, Anxious, Neutral-2) for a total of seven time points in the study. Four teams were missing one reported state anxiety score, from different conditions; missing data were due to experimenter error. The missing cells were from the following conditions: after the neutral mood induction (one missing team), after the end of the anxious mood block (one missing team), and after the anxious mood induction (two missing teams). Missing data comprised less than 3% of the total data and were replaced with the grand mean.

To look for changes in state anxiety across group types a 3 × 7 (Team Type [low anxious, mixed anxious, high anxious] × Time [baseline, post N1 induction, post N1 block, post AX induction, post AX block, post N2 induction, post N2 block]) mixed-model analysis of variance (ANOVA) was performed. Results of the analysis indicated a statistically significant main effect for team type, $F\ (2, 43) = 7.54$, $p < .01$, $\eta_p^2 = .26$. High anxious teams ($M = 20.88$, $SE = .60$) reported significantly higher scores of state anxiety, across all mood blocks, than both mixed anxious ($M = 18.50$, $SE = .60$) and low anxious teams ($M = 17.89$, $SE = .53$). There was no significant difference in reported state anxiety between mixed anxious and low anxious teams ($p > .05$).

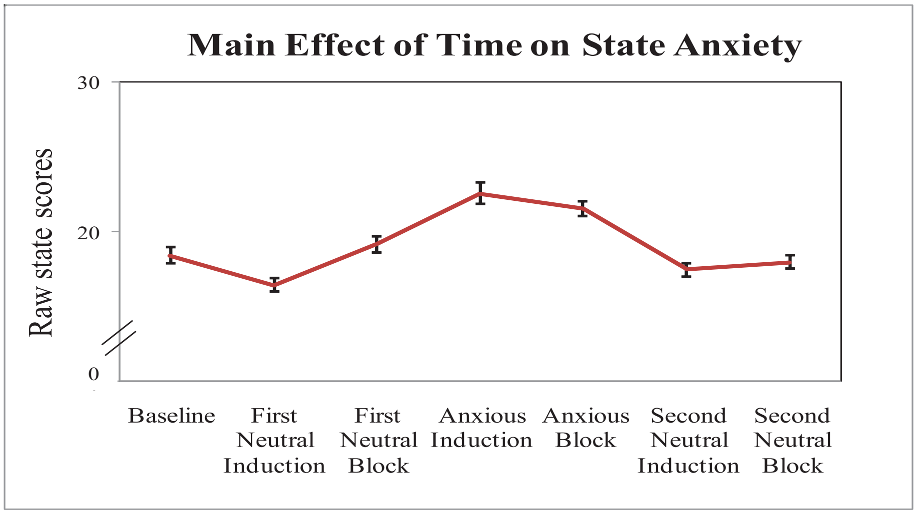

Figure 5. State anxiety scores averaged across team members for each time point. Error bars represent standard errors.

The analysis of state scores also indicated a statistically significant main effect for time, F (3.67, 157.71) = 24.25, $p < .001$ $\eta_p^2 = .361$. Figure 5 illustrates the nature of this main effect. Follow-up t-tests revealed that state anxiety measured at baseline was higher (M = 18.44, SE = .54) than scores following the first neutral mood induction (M = 16.44, SE = .46), but showed no significant difference from scores reported after the first neutral mood block (M = 19.17, SE = .51), the second neutral mood induction (M = 17.47, SE = .46) and second neutral mood block (M = 17.98, SE = .45). Baseline state anxiety did differ from state anxiety after the anxious mood induction (M = 22.58, SE = .74) and the anxious mood block (M = 21.54, SE = .52). Reported state anxiety at these two anxious time points was significantly higher than scores reported at all other time points but not significantly different from each other. Additionally, scores of reported state anxiety were lower after the first neutral mood induction than the second neutral mood induction and the end of both neutral mood blocks. Although there was no significant difference between the second neutral mood induction and the second neutral mood block, state anxiety reported at these two points was lower than scores reported after the first neutral mood block.

No other sources of variance in the analysis were significant ($p > .05$).

Stress State

Scores from a single team were missing due to experimenter error. This pair of missing cells was from survey data collected after the first neutral mood block. The empty cells were replaced with the grand mean for the condition. Engagement, distress, and worry were calculated from their respective items from the DSSQ and analyzed separately using a 3 × 4 (Team Type [low anxious, mixed anxious, high anxious] × Time [baseline, post N1 block, post AX block, post N2 block]) mixed-model ANOVA for each scale.

Engagement. Results of the analysis revealed a statistically significant main effect for team type, F (2, 43) = 5.13, $p < .01$, $\eta_p^2 = .19$, and also for time, F (3, 129) = 4.09, $p <.01$, $\eta_p^2 =$ .09. Engagement scores across all teams followed a similar pattern: engagement was highest during the study after the first ($M = 26.74$, $SE = .62$) and second ($M = 27.1$, $SE = .58$) blocks of trials compared to the baseline ($M = 25.00$, $SE = .63$) and the end of the study ($M = 26.1$, $SE =$ .53). Teams differed, overall, in reported engagement, with high anxious teams reporting lower engagement ($M = 24.2$, $SE = .80$) than both mixed ($M = 27.45$, $SE = .80$) and low anxious teams ($M = 27.10$, $SE = .70$). There was no difference between mixed and low anxious teams ($p > .05$).

The interaction for team by time was not statistically significant ($p > .05$). However, a trend within the data suggested that engagement scores reported by high anxious teams increased after the anxious mood condition ($p < .10$). Figure 6 illustrates this trend in the data.

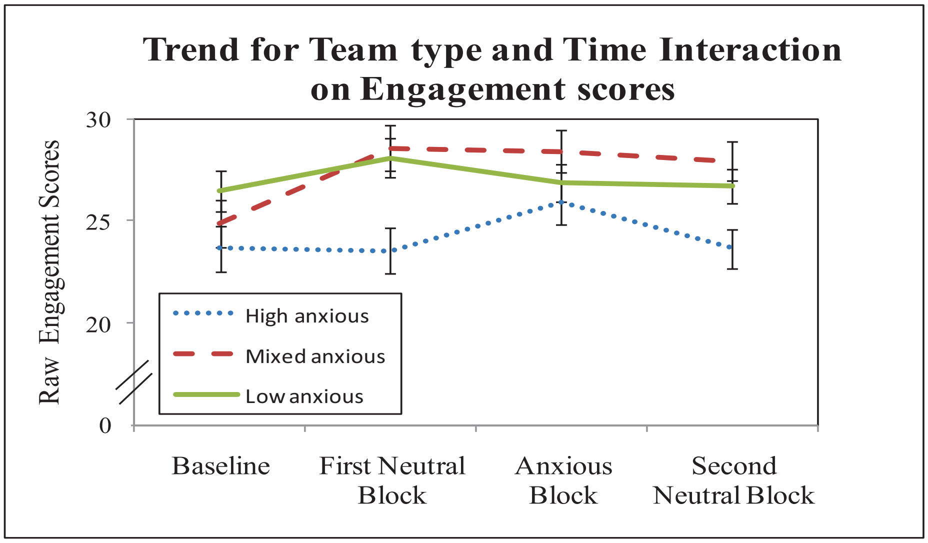

Figure 6. Engagement scores collected at four time points in the experiment: baseline, at the end of the first neutral mood block(N1), anxious mood block (AX) and the second neutral mood block (N2). Means used are averaged across teammates. Error bars represent standard errors.

Distress. The analysis indicated a statistically significant main effect for team type, F (2, 43) = 3.32, p < .05, η_p^2 = .13. A post-hoc analysis revealed higher levels of Distress was reported by the high anxious team (M = 12.50, SE = 1.05) than both mixed teams (M = 9.18, SE= 1.05) and low teams (M = 9.30, SE = .92), however the difference between mixed teams and low teams was not significant.

The main effect for time was also statistically significant, F (3, 129) = 15.31, p <.05, η_p^2 = .26. Follow-up post hoc t-tests revealed that reported distress rose between baseline (M = 8.16, SE = .82) and the end of the first neutral mood block (M = 11.29, SE = .75). Scores remained stable until the end of the anxious mood block (M = 13.02, SE = .81), which showed no significant difference from distress scores reported after the first neutral block. However, distress dropped significantly after the end of the second neutral mood block (M = 8.8, SE = .68). Baseline distress was not significantly different than distress at the end of the second neutral mood block. Figure 7 depicts this increase in score, together with a drop from the anxious mood block to the end of the experiment.

No other sources of variance in the analysis or distress were significant ($p > .05$).

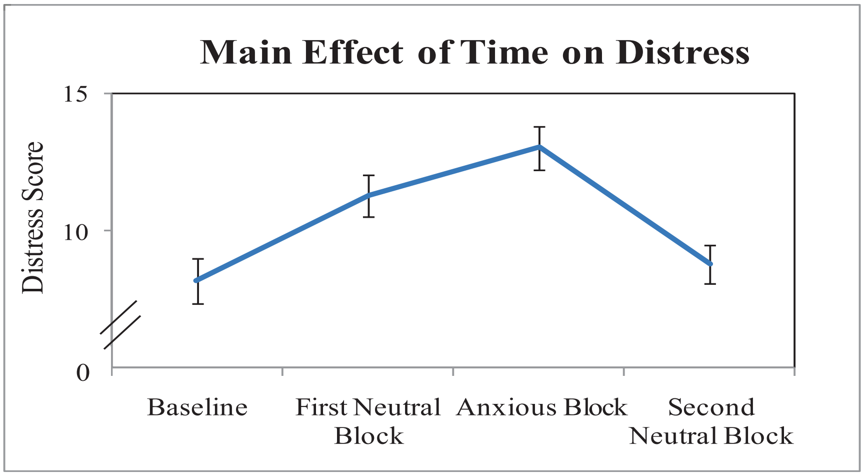

Figure 7. Distress scores averaged across team members from four points of the experiment: baseline, end of the first neutral mood block, end of the anxious mood block and after the end of the second neutral block. Error bars represent the standard error for each mean.

Worry. Results of the analysis indicated a statistically significant main effect for team type, F (2, 43) = 5.61, $p < .01$, $\eta_p^2 = .21$. Follow-up *t*-tests revealed that the low anxious team (M = 6.57, SE =1.01) reported significantly less worry than the high anxious team (M = 11.42, SE =1.15), but the mixed team did not differ (M = 10.20, SE = 1.15) in reported worry from both the two extreme groups.

There was also a statistically significant main effect for time, F (2.13, 91.73) = 33.12, $p <$ .001, $\eta_p^2 = .44$. Post hoc comparisons revealed that reported worry decreased from baseline to the end of the first neutral mood block. There was no significant difference in worry scores from the first neutral mood block and scores taken at the end of the anxious mood block, however worry was significantly lower at the end of the second neutral block than after the first neutral block (see Figure 8). The difference between worry at the end of the anxious mood block and the end of the second neutral block was not statistically significant.

No other sources of variance in the analysis of worry were significant ($p > .05$).

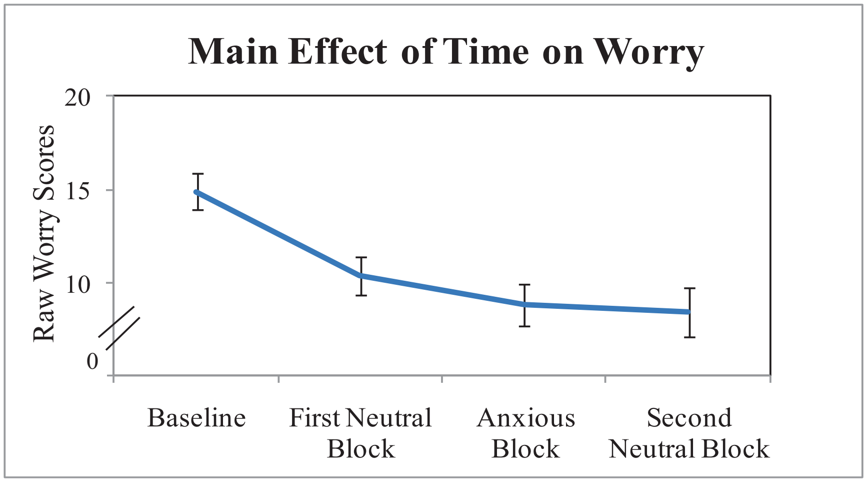

Figure 8. Scores for Worry collected and averaged across team members at four points of the experiment. Error bars represent standard error.

Subjective Workload

As mentioned previously, participants completed the NASA-TLX after each trial. Scores for each participant were averaged across each mood block for the following analyses. A 3 × 6 × 6 (Team Type [low anxious, mixed anxious, high anxious] × Time [post N1 block, post AX block, post N2 block]) × TLX Subscale [mental demand, effort, temporal demand, physical demand, performance, frustration]) mixed-model ANOVA was conducted on reported workload scores.

Results revealed that there was no significant main effect for team ($p > .05$) however there was a statistically significant main effect for time, F (2, 86) = 5.42, $p < .01$, $\eta_p^2 = .11$. Follow-up paired comparisons revealed that workload was stable across the first ($M = 56.98$, *SE*

= 1.88) and second experimental blocks (*M* = 58.57, *SE* = 2.06) but showed a significant decrease by the end of the experiment (*M* = 54.55, *SE* = 2.21).

The Time × Team Type interaction approached significance, F (3.82, 82.1) = 2.43, p = .057, $\eta_p^2 = .10$. Figure 9 illustrates a potential difference in subjective workload reported by low anxious teams at the end of the anxious block and the end of the neutral block.

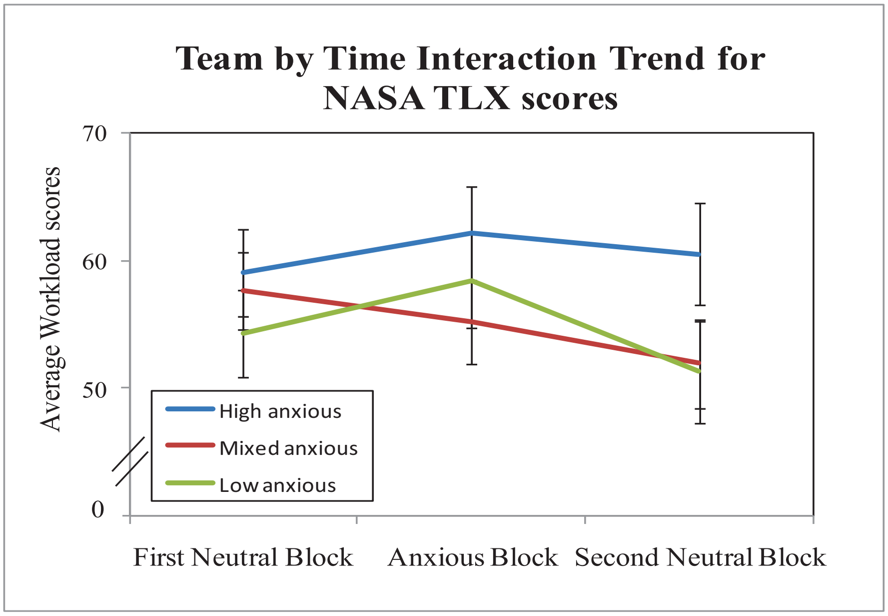

Figure 9. Mean global TLX workload scores as a function of time of administration. Error bars are standard errors.

Additionally, there was a statistically significant main effect for subscale, F (2.89, 124.06) = 55.91, $p < .001$, $\eta_p^2 = .57$, and a statistically significant interaction between time and subscale, F (5.53, 237.84) = 2.58, $p < .05$, $\eta_p^2 = .06$. Figure 10 illustrates the main effect for subscale. Follow-up *t*-tests revealed that mental demand, effort and temporal demand equally contributed to reported workload, with no significant difference between the scales. Frustration held the next largest score and was greater than both performance and physical demand, which did not significantly differ from one another.

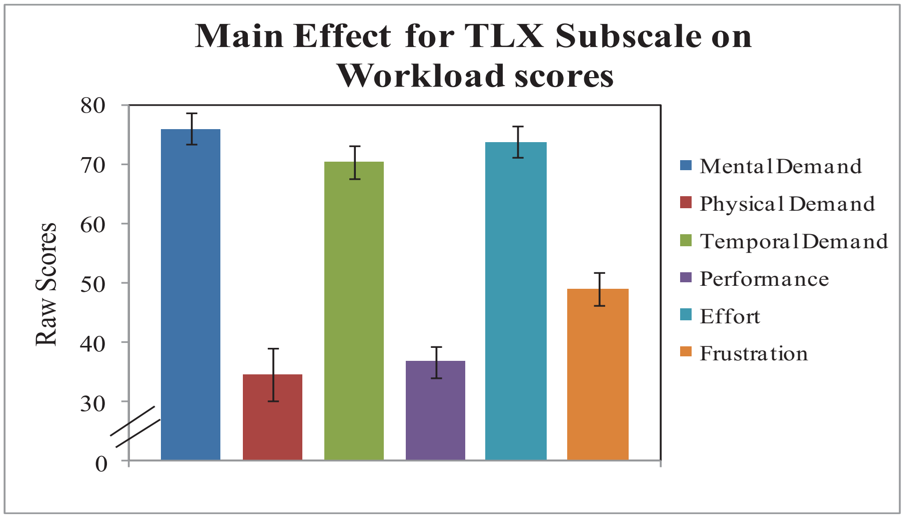

Figure 10. Mean workload ratings for the six TLX subscales, averaged across team members. Error bars represent standard errors for each mean.

To interpret the Time × Subscale interaction (see Figure 11), separate paired sample *t*-tests were performed for each subscale across the three mood blocks. The follow-up tests revealed a significant decrease in temporal demand from the end of the anxious mood block (*M* = 72.97, *SE* = 2.85) to the end of the second neutral block (*M* = 66.92, *SE* = 3.06).

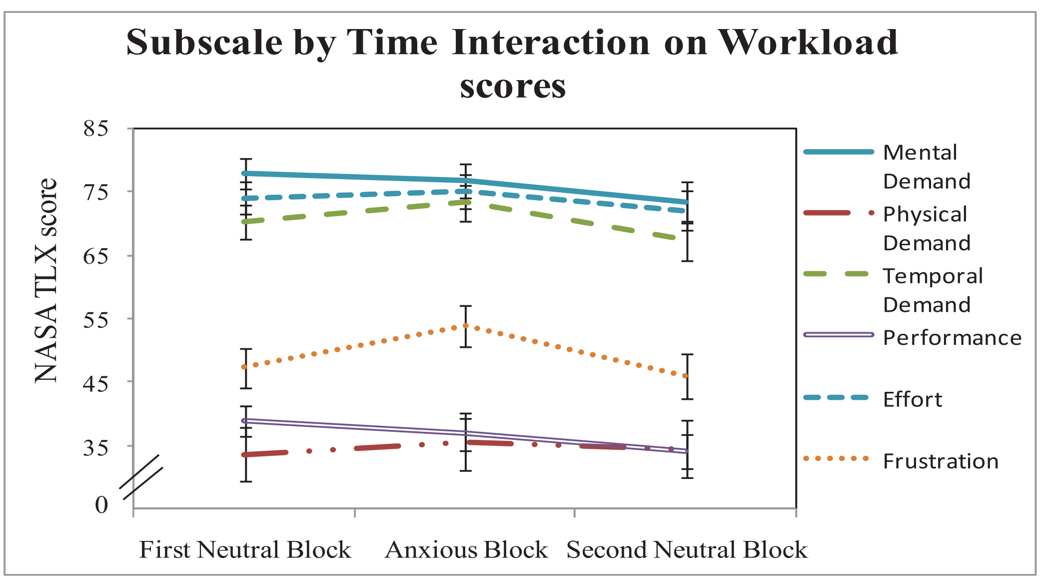

Figure 11. Mean NASA TLX scores for each subscale, averaged across team members at the end of each experimental block. Error bars represent standard error.

Change Detection Performance

Frequency data. Frequency was calculated as the proportion of detection responses to the total number of instances for each aircraft target. Change detection proportions were generally rather low and are presented below in Table 1. A 3 × 3 × 3 (Team Type [low anxious, mixed anxious, high anxious] × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Target Amity [neutral, low-threat, high-threat]) mixed-model ANOVA was performed. The main effect for team and the main effect for time did not reach significance, $p > .05$. The results of the analysis revealed a statistically significant main effect for target amity, $F\,(2, 86) = 25.65$, $\eta_p^2 = .37$, $p < .05$. Follow-up *t*-tests showed that high-threat targets were detected more frequently ($M = .38$, $SE = .027$) than both low-threat ($M = .32$, $SE = .03$) and neutral targets ($M = .20$, $SE = .03$), and that low-threat targets were detected more frequently than neutrals. The interaction between target amity and team type did not reach significance, $p > .05$; however, the trend is displayed in Figure 12.

Table 1
Means and Standard Deviations of Detection Proportions across Mood Blocks and Target types

	Neutral		Low-threat		High-threat	
Mood Block	*M*	*s.d.*	*M*	*s.d.*	*M*	*s.d.*
First Neutral Block	0.16	0.19	0.27	0.21	0.36	0.22
Anxious Block	0.19	0.18	0.34	0.25	0.39	0.21
Second Neutral Block	0.37	0.25	0.33	0.25	0.39	0.25

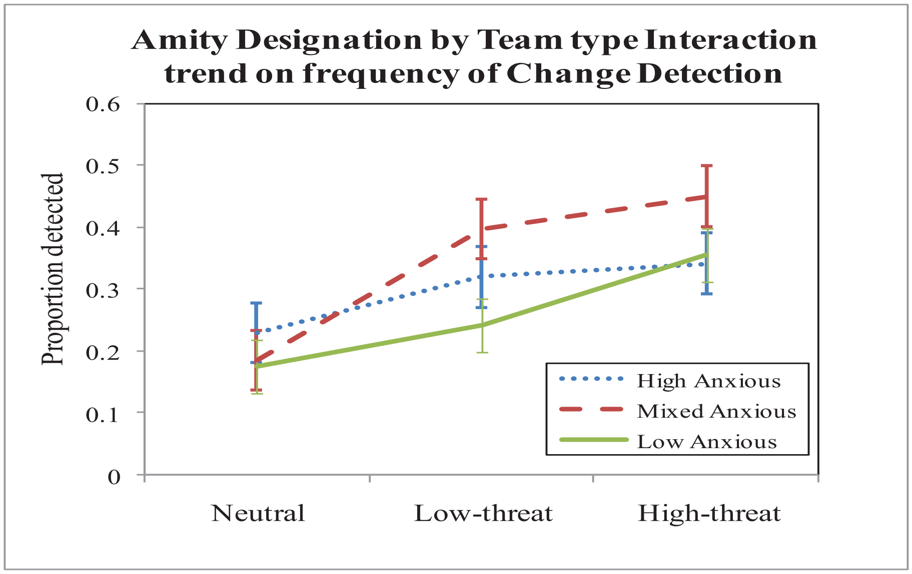

Figure 12. Average proportion of correct detections as a function of team type and target amity. Error bars represent standard errors.

Frequency of incorrect detections was the number of false alarms made during each trial ($M = 1.89$). These values were recorded for each team throughout the experiment and analyzed in a 3 × 3 × 3 (Team Type [low anxious, mixed anxious, high anxious] × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Target Amity [neutral, low-threat, high-threat]) mixed-model ANOVA. The analysis revealed no significant main effects of interactions.

Reaction Time. As a secondary analysis of change detection, reaction times (measured in seconds) associated with correct detections were log transformed. A 3 × 3 × 3 (Team Type [low anxious, mixed anxious, high anxious] × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Target Amity [neutral, low-threat, high-threat]) mixed-model ANOVA was then computed. There were no significant main effects or interactions in this analysis.

To observe the influence of trait anxiety on detection speed, a 2 × 3 × 3 (Trait anxiety [low anxious, high anxious]) × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Target

Amity [neutral, low-threat, high-threat]) mixed-model ANOVA was conducted. There were no significant main effects or interactions in this analysis ($p > .05$).

Air Defense Task Performance

Analyses for the ABM task were separated into the two aspects: offensive and defensive performance. The number of enemies attacked and the number of team assets attacked were calculated across trials for the two types of threat icons. These performance factors were also identified for each individual in a separate set of analyses. Additionally, the team measure of mean time to prosecute an enemy aircraft, recorded in seconds, was analyzed.

Number of enemy targets attacked. A 3 × 3 × 2 (Team Type [low anxious, mixed anxious, high anxious] × Time [Neutral 1 block, Anxious block, Neutral 2 block] × Threat Level [low-threat, high-threat]) mixed-model ANOVA was calculated for the number of enemy targets attacked by the team. Results of the analysis indicated a statistically significant main effect of target amity, $F(1, 20) = 10.32$, $p < .01$, $\eta_p^2 = .34$. Follow-up post hoc *t*-test revealed that low-threat targets were attacked more frequently ($M = 13.29$) than high-threat targets ($M = 12.41$). A statistically significant main effect for time was also detected, $F(1.41, 28.21) = 7.22$, $p < .01$, $\eta_p^2 = .27$. Follow-up *t*-tests indicate a small practice effect with no significant difference found between the number of attacks made during the first neutral block ($M = 12.18$) and the anxious block ($M = 12.89$), but with a significant difference between the number of attacks made during the first neutral block and number of attacks made during the second neutral block ($M = 13.47$). Additionally, the number of attacks made during the anxious block was significantly less than the number of attacks made during the second neutral block.

Time to prosecute targets. To observe biases toward target amity in ABM performance, time to prosecute targets was calculated as the amount of time elapsed, in seconds, from the appearance on screen of an enemy to its destruction. The mean time to prosecute enemy targets was analyzed in a 3 × 3 × 2 (Team Type [low anxious, mixed anxious, high anxious] × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Threat Level [low-threat, high-threat]) mixed-model ANOVA. There was again a significant main effect for target amity, F (1, 20) = 18.05, $p < .001$, $\eta_p^2 = .47$. Follow-up *t*-tests indicated that teams were faster to kill low-threat icons (M = 102.45) than high-threat icons (M = 111.87).

Results indicated the main effect for time was significant, F (2, 40) = 9.24, $p < .001$, $\eta_p^2 = .32$. Follow-up *t*-tests revealed a mild effect of practice; time to kill enemies improved between the first neutral block (M = 112.58) and the second neutral block (M = 102.72), but time to kill enemies did not differ between both neutral block and the time to kill enemies in the anxious block (M = 106.19).

Defense. A 3 × 3 × 2 (Team Type [high anxious, mixed anxious, low anxious] × Time [Neutral-1 block, Anxious block, Neutral-2 block] × Threat Level [low-threat, high-threat]) mixed-model ANOVA was calculated for the number of attacks made on team aircraft by the two types of enemy aircraft in each mood block. The results of this analysis indicated a statistically significant main effect for team type, F (2, 43) = 3.72, $p < .05$, $\eta_p^2 = .15$. This effect is graphically displayed in Figure 13. Follow-up *t*-tests revealed that aircraft controlled by low anxious teams suffered more attacks (M = 1.36) than those controlled by high anxious teams (M = 1.02). Mixed anxious teams (M = 1.34) sustained more attacks than high anxious teams, but did not differ from low anxious teams.

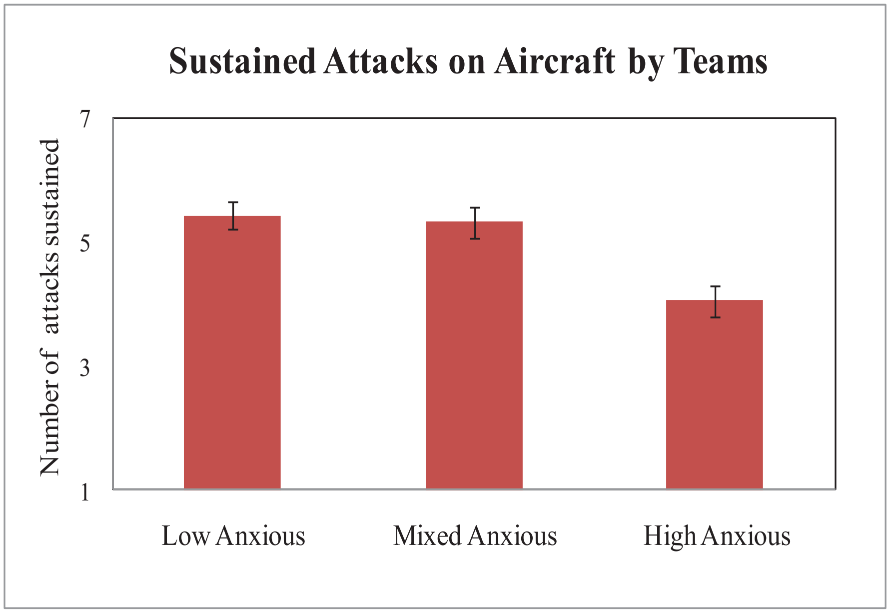

Figure 13. Average frequency of attacks sustained by team aircraft, across all trials.

Correlational Analyses

In order to understand the relationships between performance and individual differences in trait anxiety and the multidimensional measures of state, several correlational analyses were run. The following section shifts focus from analyses of mean levels of subjective state and performance indices across the three team types, to individual differences in the data pooled across teams.

Intercorrelations of trait and state measures. Correlation coefficients were computed among the baseline scores for state anxiety, the three scales of the DSSQ, and trait anxiety. The results of the correlational analyses, presented in Table 2, show that trait anxiety was positively correlated with state anxiety upon beginning the study as well as baseline measures of distress and worry. Baseline engagement was negatively correlated with trait anxiety, indicating that as trait anxiety increased, reported engagement at the start of the study decreased. Baseline engagement was also negatively correlated with baseline measures of distress, worry, and state anxiety. As expected, STPI state anxiety was associated with both distress and worry.

Table 2
Correlations among Baseline State Measurements and Trait Anxiety (N=46)

	Trait Score	Engagement	Distress	Worry	State Anxiety
Trait Score	-----				
Engagement	-0.35*	-----			
Distress	0.42**	-0.54**	------		
Worry	0.34*	-0.26	0.62**	-----	
State Anxiety	0.53**	-0.44**	0.81**	0.48**	-----

*Correlation is significant at $p < .05$
** Correlation is significant at $p < 0.01$

Correlation coefficients were calculated between trait anxiety and state anxiety at each time period. The results of these analyses show variations in this relationship and are presented in Table 3. Trait anxiety was positively related to all scores of state anxiety, except for state anxiety reported after the anxious mood induction, and following the first neutral and anxious performance blocks.

Table 3
Correlations among State Anxiety and Trait Anxiety (N=46)

	Trait Anxiety	Baseline	Neutral Mood Induction	First Neutral Block	Anxious Mood Induction	Anxious Block	Neutral Mood Induction	Second Neutral Block
Trait Anxiety	-----							
Baseline	0.53**	-----						
Neutral Mood Induction	0.44**	0.47**	-----					
First Neutral Block	0.15	0.39*	0.49**	-----				
Anxious Mood Induction	0.18	0.47**	0.06	0.38*	-----			
Anxious Block	0.18	0.32*	0.16	0.27	0.40*	-----		
Neutral Mood Induction	0.38*	0.45**	0.75**	0.37*	0.04	0.24	-----	
Second Neutral Block	0.38*	0.38*	0.69**	0.41*	0.19	0.27	0.67**	-----

State Anxiety measures collected Post Mood Induction and Post Experimental Mood Block
**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Similarly, correlations were calculated between trait anxiety scores and the three scales of the DSSQ in each mood block and are presented in Table 4. Trait anxiety was significantly negatively correlated with engagement at both baseline and the end of the second neutral block. Trait anxiety scores were consistently positively correlated with worry scores throughout the experiment. Distress was only positively correlated with trait anxiety at baseline (r = .42).

Table 4

Correlations between the dimensions of the DSSQ and Trait Anxiety

	Engagement	Distress	Worry
Baseline	-0.35*	0.42**	0.34*
Neutral 1 Block	-0.28	0.07	0.32*
Anxious Block	-0.12	0.07	0.32*
Neutral 2 Block	-0.30*	0.17	0.41**

DSSQ collected Post Experimental Mood Block
**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

The DSSQ was also correlated with state anxiety and NASA-TLX workload after each mood block, as shown in Table 5. Distress and worry were consistently positively correlated with state anxiety. Baseline state anxiety did not correlate with any of the NASA-TLX scales. Correlations between the NASA-TLX and state anxiety were most consistent for the frustration, although some further positive associations between state anxiety and other workload components were found. Table 5 lists the subscales of the NASA-TLX which shared some association with state anxiety scores. In addition, trait anxiety did not correlate with any of the subscales of the NASA-TLX.

Table 5
Correlations between the NASA-TLX subscales and State Anxiety Scores

Subjective Measures	First Neutral Block	Anxious Block	Second Neutral Block
<u>NASA-TLX</u>			
Mental Demand	0.15	0.31*	0.17
Effort	0.17	0.31*	0.14
Physical Demand	0.30*	0.29	0.24
Frustration	0.39**	0.46**	0.21
<u>DSSQ</u>			
Engagement	-0.20	0.03	-0.21
Distress	0.65**	0.44**	0.55**
Worry	0.33*	0.50**	0.47**

NASA-TLX and DSSQ collected Post Experimental Mood Block.
**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Intercorrelations of performance indices. Correlational analyses were performed separately amongst (1) change detection measures and (2) ABM performance measures, and then between both change detection and ABM performance. Beginning with change detection, measures of detection were intercorrelated across all mood blocks. This analysis revealed some individual differences in detection regardless of threat level. In the first neutral mood block, detection of neutral targets was positively correlated with detection of high threat targets (r = .31), only. Detection of high threat targets was also positively correlated with detection of low threat targets (r =.31). The anxious mood block revealed that detection of each target was positively correlated with one another. Detection of high threat targets was correlated with detection of low threat targets (r = .49) and with detection of neutral targets (r = .37). In this block, detection of neutral targets and low threat targets were correlated (r = .32). In the final block, there was a larger association between detection of high threat targets (r = .49) and neutral targets and also with low threat targets (r = .52). Again, detection of neutral targets was positively correlated with low threat targets (r = .52).

Next, correlation coefficients were calculated between offensive and defensive measures. Measures of offensive performance, i.e., number of low-threat icons attacked and number of high-threat icons attacked, were consistently intercorrelated across mood blocks. During the first neutral block, number of low-threat icons attacked was positively correlated with the number of high-threat icons attacked (r = .53) and this relationship was statistically significant in the anxious block (r = .48) and the second neutral block (r = .40). Defensive performance measures, *i.e.,* number of attacks from low threat icons and number of attacks from high threat icons, were significantly positively intercorrelated, but only in the anxious mood block (r =.30). The intercorrelations from the first neutral mood block were near zero (r = .04). Also, the correlation calculated in the second neutral mood block did not reach significance but showed the same positive trend (r = .27) found in the anxious block.

Correlation coefficients were calculated for associations between defensive and offensive scores, also. There were no significant relationships between the measures in the first neutral block, but there was a significant positive correlation in the anxious block between the number of times aircraft were attacked by low-threat icons and the number of high-threat aircraft attacked (r = .34). In the second neutral block, the number of attacks made by low-threat aircraft was positively associated with the number of attacks made on low-threat aircraft (r = .36). No other relationships were significant. Thus, there was only a weak tendency for good offense to occur together with poor defense.

Finally, to observe the relationship between change detection ability and overall performance in the ABM simulation, correlational analyses were run between measures of change detection and measures of battle management across each block of trials. It might be expected that change detection frequency would be positively correlated with attacks on enemy aircraft (good offense) and negatively correlated with attacks made by the enemy (poor defense). Findings are presented in Table 6. In the first neutral block, good change detection appears to accompany some indices of superior battle management. Results are slightly different amongst the set of detected targets within each threat level. For low-threat targets, a decrease in attack frequency by low-threat aircraft was associated with an increase in detection of changes into low-threat aircraft (r = -.49). In the case of high-threat aircraft, improvement in detection of changes into high-threat aircraft was associated with an increase in the number of attacks made on high-threat aircraft (r =.36). This trend was maintained in the anxious block, but did not reach significance.

Table 6
Correlations between the Change Detection and Performance measures

	First Neutral Block		Anxious Block		Second Neutral Block	
	Low-threat Detection	High-threat Detection	Low-threat Detection	High-threat Detection	Low-threat Detection	High-threat Detection
Low-threat						
Attacks on	0.10	0.20	0.00	-0.04	0.09	0.03
Attacks made by	-0.49**	-0.11	-0.21	-0.17	-0.08	-0.09
High-threat						
Attacks on	0.16	0.36*	-0.19	0.23	-0.24	0.03
Attacks made by	0.02	-0.10	-0.09	0.02	-0.07	-0.32*

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

Correlations of state measures and change detection. Correlation coefficients were calculated for the different state scales of the DSSQ, state anxiety and frequency data at each mood block. There were no other significant correlations between detection frequencies and engagement, worry and anxiety. However, distress was consistently negatively associated with detections of all three aircraft types, although these relationships did not reach significance in most blocks. In only the anxious mood block, detection of high-threat icons was negatively correlated with distress (r = -.30). As shown in Table 7, this trend was present across all aircraft types and across all mood blocks.

Table 7
Correlations between Change Detection and Distress across all Mood Blocks

	Neutral	Low-threat	High-threat
Neutral 1 Block	-0.12	-0.16	-0.21
Anxious Block	-0.16	-0.23	-0.30*
Neutral 2 Block	-0.07	-0.10	-0.14

Distress collected Post Experimental Mood Block
*Correlation is significant at the 0.05 level (2-tailed).

Correlations of State measures and Air Battle Management. Both attacks made and attacks suffered by low-threat and high-threat enemies were included in a correlational analysis with state anxiety and the three subscales of the DSSQ at each of the experimental mood blocks. The analyses revealed that there were no state level correlations with the performance data in any of the mood conditions.

Trait effects on performance. Correlational analyses were performed on trait anxiety scores and measures of performance. Detection frequency only showed a significant relationship with trait anxiety in the second neutral mood block. Low-threat detections were positively correlated with trait anxiety (r =.29), indicating that detection rate increases with higher scores of trait anxiety. Coefficients of correlation were calculated for trait anxiety and measures of offensive and defensive performance for each of the experimental blocks. Results of the first neutral block show that trait anxiety was negatively correlated with the number of times assets were attacked by low-threat enemies (r = -.39). The anxious block revealed negative correlations between trait anxiety and both the number of attacks suffered from low-threat enemies (r =-.30) and from high-threat enemies (r =-.31). In this block, it appeared that trait anxiety was related to a strategy characterized by better defense (fewer enemy attacks) but poorer offense (fewer attacks on enemy). Table 8 shows the relationship between trait, state and state measures and the two measures of performance reviewed above.

Table 8
Correlations between Trait and Performance variables

	Attacks on Low-threat icons	Attacks on High-threat icons	Attacks made by Low-threat	Attacks made by High-threat
First Neutral Block	-0.15	-0.20	-0.40**	-0.13
Anxious Block	0.05	-0.31*	-0.30*	0.24
Second Neutral Block	0.02	-0.19	-0.02	-0.06

**Correlation is significant at the 0.01 level.
*Correlation is significant at the 0.05 level.

Discussion

The current study was an investigation of the impact of stress and anxiety on change detection in two-person teams performing a simulated ABM task. The findings supported, at least partially, several hypotheses of the study and revealed some modest relationships between anxiety variables and performance. As evidenced by high workload ratings and poor change detection performance, the simulated ABM task was generally attentionally demanding. The difficulty of the task was also evident in the weakness of practice effects. The majority of performance measures showed no systematic improvement across blocks of trials, including defensive performance and CB measures. Practice effects were limited to offensive performance, both in the temporal decrease in response time to attack enemy targets, and the increase in number of attacks on enemy targets. Also the mood induction utilized was successful in elevating state anxiety and distress, similar to Matthews et al. (2010). The aim to create teams that differed in affective state variables was successful, as evidenced by team differences in state anxiety, engagement and worry. The observed relationships between the anxiety and performance variables were generally modest in magnitude. Overall, some evidence was found for trait anxious subjects adopting a more defensive strategy.

Findings related to trait anxiety effects on subjective state, change detection performance, and ABM performance are discussed in more detail below. Additionally, limitations of the current study and applications will be addressed. Lastly, the impact of anxiety, subjective state and change detection on ABM operations and future research applications are discussed.

Trait Anxiety and Subjective State

Several hypotheses were made regarding relationships between trait anxiety and subjective state. Viewing trait anxiety as a stable personality trait which inclines an individual to experience more intense and more frequent states of anxiety, it was hypothesized that high trait anxious individuals, and thus high trait anxious teams, would report higher state anxiety in response to the anxious mood induction. Analyses of STPI scores partially supported these hypotheses. The main effect for time in the initial ANOVA revealed that the anxious mood induction was successful in manipulating state anxiety across all participants, supporting H1. The anxious mood induction and the anxious experimental block which followed showed the highest ratings of state anxiety. The main effect for team revealed that high anxious teams, comprised of two high anxious team members showed higher levels of state anxiety, across all mood blocks, compared to both mixed and low anxious teams. Correlational analyses conducted on trait scores and state anxiety suggest that the two variables were generally positively associated, as expected (Spielberger, 1972), but the correlation was non-significant during the first two blocks of trials, contrary to H2. Instead, it seems that the anxious mood manipulation and trait anxiety had independent, additive effects on anxiety.

Correlations between trait anxiety and state anxiety also showed no tendency to increase during the anxious mood trial block, as the Spielberger (1972) theory might predict. In fact, the correlation seemed higher prior to performance, and during the final, neutral block of trials. In light of the objective to create a level of task demand that might closely resemble threat of ABM operations, the weakened relationship between trait and state anxiety may be driven by the successful manipulation of task difficulty. Possibly, individual differences in state anxiety in the initial block of trials and during the anxious mood manipulation were driven by the external factor of the inherent difficulty of the task, rather than personality. Only when the task became more familiar and somewhat less demanding, as evidenced by the lowered workload in the final block of trials, did the trait-state correlation once more become significant. Trait anxiety may become more salient when the task context becomes more open to personal interpretation, rather than being unequivocally demanding. Spielberger (1972) also suggests that trait anxious individuals are especially vulnerable to ego threat; in the first two blocks of trials, participants may have attributed task difficulty to the task itself, rather than to any personal failings. In addition, working as part of a team may have diffused the individual's sense of personal responsibility.

Previous work has revealed that state anxiety, measured by the STPI (Spielberger, 1996) was positively correlated with the distress and worry dimensions of the DSSQ (Matthews & Campbell, 2010). Thus, it was hypothesized that distress and worry would exhibit trends similar to that of state anxiety. It was anticipated that distress and worry would increase during the anxious mood block, and that high anxious teams would report higher levels of both (H3). Findings from analysis of the DSSQ partially supported this hypothesis in that levels of distress did increase and decrease during the task similarly to state anxiety. This occurred across all teams and showed that the effects of the mood blocks were generally similar on distress and anxiety. Distress rose after the first neutral block, remained stable through the anxious block, and dropped after the end of the second neutral block. Worry decreased after the first neutral mood block and remained relatively stable before decreasing again after the second neutral block. The initial task-induced elevation of distress relative to baseline can be interpreted as an indication that the experimental task was attentionally demanding. Matthews and Campbell (2010) present distress as representing a lack of confidence, and found that performance of working memory tasks tend to increase distress and lower worry; this pattern is suggested to represent refocusing of attention away from self-referent thoughts (worry) to processing high task demands. Team differences supported the hypothesis that the distress and worry scales of the DSSQ would mirror effects of trait anxiety (H3). High anxious teams reported higher distress and worry than low anxious teams. Team type also influenced engagement; high anxious teams reported lower engagement than low anxious teams (see Figure 6). Engagement is a reflection of resource availability and high task engagement is associated with high performance in attentionally demanding tasks (Matthews & Campbell, 2010). Although engagement did not appear to be directly linked to performance in the current study, a trend indicating high engagement across all teams during the anxious block (see Figure 6) might explain why high anxiety teams did not exhibit any performance decrement.

Contrary to H4, teams did not differ in subjective workload, indexed by scores on the NASA–TLX. However, there was a trend towards the high anxiety teams reporting high workload throughout the task, whereas lower-anxiety teams tended to show declining workload in the final performance block (see Figure 9). Thus, effects of trait anxiety were more apparent in subject state than in workload, and the main effect of team type on state anxiety cannot only be a product of workload-elevation in high anxiety teams. To the extent that workload is higher in high trait-anxiety teams towards the end of the task, the effect might reflect either task demands of sustaining attention, or social demands of maintaining constructive interaction between team partners.

The pattern of subjective state associated with high trait anxiety might suggest that these individuals were vulnerable to performance decrement. Lower task engagement and higher distress have been linked to impairments in working memory and resource availability (Matthews & Campbell, 2010). According to PET (Eysenck & Calvo, 1992) worry competes with task processes for attentional resources and may reduce the efficiency of processing. This reduction in efficiency may cause high anxious individuals to exert effort to maintain performance. The trend for an increase in engagement during the anxious mood block may indicate high anxious teams' use of compensatory effort. High levels of distress and state anxiety may represent the strain of this effort, but these effects were not generally evident in indices of task performance, an issue which will be covered in detail shortly. Broadly, compensatory effort may have helped to maintain performance in higher-anxiety individuals, despite their compromised subjective state. These results suggest that in operational settings such as ABM environments, there may be many factors contributing to team member stress, and that monitoring individual and team performance and workload only may be insufficient for exploring the stress process.

Change Detection Performance

There was a fairly consistent trend for the detection measures for different types of aircraft to be positively intercorrelated with each other, and to be positively correlated across blocks of trials. Therefore, there was some consistency in individual differences in performance; the measures of overall offensive and defensive performance also showed some consistency. Change detection performance was generally poor, as observed in low hit proportions across all team types ($M = .30$). An analysis of error rate showed false alarm rates were comparable across teams and across blocks of the study. The data thus suggest extensive CB, although it is possible too, that participants were aware of change but did not respond to the aircraft concerned because they were preoccupied with more immediate threats to their assets. Such a focus would represent a response bias. Whether or not participants were generally conscious of change stimuli, the difficulty of the task difficulty may have encouraged a "reactive" response strategy to incoming targets that indirectly influenced change detection. That is, subjects may have taken a defensive approach to enemy attack by only attacking enemies after they entered friendly airspace. Perhaps for this reason, correlations between change detection and performance measures from the air battle task revealed only a weak relationship. In the case of low-threat targets, high detection of these aircraft lead to reduced frequency of attack by them. However, high detection of changes of unknowns into high-threat planes was related to higher attacks of high-threat planes. These correlations were inconsistent across all conditions but generally suggest that strategy in air battle may have impacted change detection.

Change detection performance revealed that amity change did influence attention (H5). As found by Knott et al. (2010), neutral aircraft were detected less frequently than changes that imposed threat to team assets (i.e., changes to low- or high-threat aircraft). Given that the different ‘post-change’ icons appear to be of similar salience, this effect of icon type might represent a differential response bias for more dangerous icons. The manipulation of threat level across icons allowed for the observation of an attentional preference for threat commonly observed in studies of anxiety bias to selective attention (see Bar-Haim et al., 2007, for a review). Thus, aircraft that posed higher threat to assets, both aircraft and civilian camps, were a priority.

It was expected that high trait anxiety would be associated with greater CB and longer reaction times, and thus high anxious teams would show greater CB (H6). However, there were no team differences in detection frequency. This finding suggests that, as found by Knott et al. (2010), the task relevance of the change within the simulation environment influenced detection. Higher threat level indicated the ability to attack more assets, specifically civilians and aircraft, which translated into a greater impact on overall score. If left unchecked, high threat icons could attack civilian camps, which could not evade enemy fire, resulting in a decrease in defensive score. This strategy appears to be consistent across differences in teams and state levels. The motivation to carry out task objectives despite subjective strain is implied by the combination of high engagement and high distress on the DSSQ. Change detection for high-threat aircraft was found to be negatively correlated with distress, but only in the anxious block. This finding suggests that, overall, high-threat icons were treated as a detection priority. However, in consideration of the elevated levels of distress reported across all teams in the anxious mood block, it can be suggested that the correlation of change detection and distress in the anxious block (see Table 7) is an indication that detection was negatively impacted by stress.

Analysis of change blindness did not uncover any effects of either the anxiety manipulation or state anxiety. A minor finding may be shown within the correlational analyses of trait anxiety on detection. In the last neutral mood block, trait anxiety was positively correlated with detection of low threat icons. This suggests a relationship between trait anxiety and change detection that is consistent with theories of attentional bias to threat. As mentioned, trait anxiety is linked to the interpretation of threat when little to no threat might be observed. The relationship between trait anxiety and detection of low-threat icons may be a weak representation of the anticipated preference to search for threat in high trait anxious individuals (H6). Perhaps the attentional bias caused by anxiety is generally too subtle to be observed in the complex setting of team-based C2 operations. Another explanation for these weak effects may be that high anxious individuals in the current study were effective at coping with their anxiety and compensating for its effects on efficiency, consistent with PET (Eysenck & Calvo, 1992).

Air Defense Task Performance

It was hypothesized that ABM performance would be negatively impacted by higher state anxiety (H7). However, during the anxious mood block offensive performance improved in the air defense task across all teams. State anxiety did not negatively impact the number of enemies attacked or the time to prosecute enemies. Perhaps offensive performance posed the lowest demand on attention. Attacking an enemy required noticing incoming enemies, executing a move towards the enemy and attacking upon arrival. In light of Miyake et al.'s (2000) model of attention, this course of action requires simply shifting attention momentarily to the incoming enemy long enough to start movement, and then updating the status of this process later. Change detection, however, requires continuous updating of working memory to account for all unidentified aircraft and identified enemy targets. Thus, the effect of practice may be due to the comparative difficulty between offensive performance and change detection but may also represent the strategy used. The operator could plan several attacks at once and wait to execute the attack once the target was within range. This strategy would compete with the detection of changes in unidentified aircraft because attention would be focused on incoming enemies. Therefore, good change detection performance would be related to better air battle management. This relationship was revealed in correlations between detection of high-threat targets and attack of high-threat targets.

Defensive performance was not impacted by state anxiety, but exhibited a surprising sensitivity to trait anxiety. Defensive performance of low trait anxious teams was worse than defensive performance of high anxious teams, indicated by low anxious teams' higher susceptibility to attack in general (see Figure 13). Additionally, mixed anxious teams suffered more attacks on own aircraft than high anxious teams, suggesting that the poor defensive performance exhibited by low anxious individuals may be present in the mixed team and responsible for reducing overall defensive performance. Correlational analyses provide some additional evidence for this trait anxiety effect on ABM performance. In the first neutral block and the anxious mood block, trait anxiety was negatively correlated with the number of attacks suffered from low-threat enemy targets. Trait anxiety was also negatively correlated with the number of attacks suffered from high-threat enemy targets, but only in the anxious mood block. Thus, while the data are not entirely straightforward, the general trend was for high trait anxious individuals to experience fewer attacks, especially in the anxious mood block. Perhaps, high state anxiety accentuates the defensive tendencies of high trait anxious individuals.

It was suggested initially that in stressful operational contexts such as ABM operations, anxiety might be a disadvantage. However, apart from the consistent but mostly nonsignificant association between distress and CB, none of the various anxiety factors related to performance impairment. Thus, the vulnerability of the ABM operator to disruption of attention due to high state anxiety remains somewhat unclear. One feature of the subjective state response, that contrasts with findings on laboratory studies of sustained performance (Matthews et al., 2010), is that task engagement was maintained at a fairly high level throughout the task. The ABM scenario may have held enough interest for participants to support the continued compensatory efforts described by PET that offset anxiety impairments in processing efficiency.

Finally, team differences in defensive performance might indicate a performance benefit of high trait anxiety. Although low anxious teams reported lower levels of stress and anxiety, they sustained more attacks on their aircraft than high anxious teams. It could be said that preferential processing of threat, suggested by studies of anxiety bias on attention (Bar-Haim et al., 2007), drove high anxious teams' effective and evasive behavior.

Practical Applications

Findings from the current study have several practical applications. Detection performance results may inform the design of tactical displays. The current study embedded a numeric verification task into the ABM simulation to serve as a distractor screen, similar to tactics used in change blindness studies which obstruct motion transients (Rensink, 2002). This design may have successfully contributed to change blindness. Therefore, a simple consideration for the design of displays would be avoidance of pop-ups that distract operators from the current task display.

Additionally, tactical displays may also implement alarms based on urgency mapping to notify operators of a change. Urgency mapping is a method for appropriately designing alarms, based on acoustical parameters, to reflect the urgency (i.e., need for rapid response) of the event and improve learning of the alarm (Edworthy & Meredith, 1993). An additional benefit of this method would be the reduction of attentional distraction in anxious operators by informing the operator of the level of threat/urgency related to an event. Because anxious individuals have a tendency to distraction in the face of potential threat (Bar-Haim, et al., 2007) urgency mapping might assist operators in disengaging from events that do not require immediate attention.

The effects of anxiety may be of importance in the area of selection at both an individual level and team level. Trait anxiety raised subjective ratings of stress and anxiety but, although high trait anxiety appeared to be related to a defensive strategy, high trait anxiety was not generally detrimental to performance. It may be that the anticipated negative effects of anxiety were attenuated by the presence of a team setting. The effects of anxiety are driven by cognitive appraisals of inadequacy and apprehension of evaluation (Sarason et al., 1990). Perhaps the team shielded trait anxious individuals from the impact of full evaluation anxiety which may be felt if participants were working in isolation. Thus, the study provides no evidence for a policy of selecting only low trait-anxious individuals for air defense operations. However, it may be advantageous to explore methods for alleviating state anxiety in susceptible individuals, and to train personnel in strategies that balance offense and defense. The study also shows that selection systems should not necessarily rely on evidence on the effects of trait anxiety in operators performing monitoring tasks in isolation.

Additionally, the extent to which personalities of team members are complementary may be considered. The selective attention bias characteristic of high trait-anxious individuals may support evasion of enemy attacks, as shown in this study, and greater effort assigned to visual search for threats (Matthews et al., 2010). On the other hand, trait anxiety (and neuroticism) is associated with deficits in executive control (Eysenck et al., 2007), and vulnerability to the social pressures of team work (Guznov et al., 2010). The benefit/cost ratio of the high trait anxious operator might be maximized by employing mixed-anxiety teams, in which the two individuals are assigned different roles. The high-anxiety person might be tasked with defense, and the low-anxiety person with pre-emptive attacks on enemy units. Further research would be necessary to determine how the operations of two such individuals might be best coordinated, and on how communication between individuals of differing threat sensitivities might be facilitated. For example, a high anxious teammate may serve as an alert to the team that other, perhaps less threatening, targets may still warrant attention. Similarly to the objectives of Crew Resource Management (Salas et al., 1999), teams may be trained to know and maximize the abilities of team-members specific to their traits. For example, if trait anxiety is correlated with detection of low-threat icons, in the context of an ABM team the operations director should seek to place this person in charge of monitoring minor threat icons.

These issues relating to selection may be leveraged to inform training recommendations. In addition to understanding the behavioral tendencies of other teammates, team training might involve learning and gaining expertise in identifying a team mate's coping strategy. Identifying the behavioral cues which indicate that a fellow team mate is under stress may allow an operator to provide his team mate support prior to performance decrements. This proposed training would create something similar to Rentsch and Woehr's (2004) Team Member Schema Similarity (TMSS). This model takes into account the knowledge within each individual which then filters the communication carried out within the team. According to Rentsch & Woehr (2004), TMSS can be information regarding how team members might handle stress or even team member personality. This information provides the team member a heuristic for interpreting their fellow teammates' communication which, if inaccurate, may influence instability within the team (Rentsch & Woehr, 2004). Thus, in relation to trait anxiety, training to promote TMSS would reduce social or evaluative anxiety derived from team interactions.

Limitations

The generalizability of current findings are somewhat limited by participant demographics. Participants in this study were college-aged students from the local area who did not have training in ABM operations and may also lack the specific cognitive abilities that influence selection for the ABM operator position. Participants also lacked the training and experience of real operators. However, findings may still be amenable to testing theory-driven predictions of how trait anxious and non-trait anxious individuals may perform in a complex simulation. Such tests may then inform subsequent (typically, more expensive) investigations of anxiety and attention in serving personnel.

Another limitation to this study was the low power associated with our between subjects variables. Lack of power makes it difficult to determine whether trends such as the consistent, but mostly non-significant, negative association between distress and change detection (Table 7) represent a genuine finding. Lack of power is partly due to the difficulty of screening for individuals with extreme trait anxiety levels. In order to observe differences in attention, subjective state, and performance between high and low trait anxious individuals, participants with STPI scores that were within ±.5 standard deviations of the normative mean for trait anxiety were excluded from the study. This restriction in addition to the challenges of coordinating team research (i.e., matching team member availability) made achieving the desired sample size difficult. Related to this limitation in recruitment, the utilized health questionnaire excluded high anxious participants who were treated for mood-related disorders either currently, or within the past 3 years. This questionnaire was created to protect vulnerable, clinically anxious participants from any potential risk associated with stress manipulations. Treatment for mood-related disorders is liable to positively correlate with trait anxiety and thus reduced our access to high trait participants.

The manipulation of stress in this study may be limited in its ecological validity. Although our induction was successful, and mood inductions are generally valid and reliable (Mayer et al., 1995), it is unclear how much the emotions elicited resemble, in magnitude or quality, those arising from real-world contexts. Part of the difficulty lies in the fact that real-world operator stress typically arises from multiple source and stress responses will differ across individuals. Pertaining to this is the limitation in validity of our simulated ABM task. True ABM involves multiple operators, and so, if the cost and effort of teamwork is more demanding and stressful than in the two-person situation, our simulation may not have fully replicated this quality. Additionally, in the real-world there are consequences to a missed detection that cannot be compared to a missed point. Therefore, knowledge of the potentially lethal dangers of poor ABM performance may be a stressor that cannot be manipulated in laboratory settings, despite the complexity and sophistication of the simulation. In addition, with experience, operators may acquire coping strategies for handling stress. Matthews and Campbell (2010) found that the distress response to a time-pressured working memory task attenuated (but did not disappear) across multiple days of testing. Due to these limiting factors, the findings from the current study may not generalize to ABM operators in real-world missions. Additionally, other measures of performance and state which will be discussed below could increase sensitivity to the effects of anxiety or state on change detection in an ABM context.

Future Studies

Future research might benefit from the use of psychophysiological measures to monitor electrical activity in the frontal cortex via electroencephalography and event-related potentials

(EEG & ERP; Coles & Rugg, 1995; Low, Leaver, Kramer, Fabiani & Gratton, 2009). These tools might uncover any additional effort exerted by individuals due to both trait and state anxiety. Specifically, EEG/ERP methods may address one of the limitations of the change blindness paradigm, i.e., the possibility that the change event is processed implicitly without reaching conscious awareness (see Busch, Frund & Herrman, 2010, for an account of evoked potential markers for components of change detection). EEG findings could be combined with measures of heart rate variability or voice stress to improve our understanding of how stress, via state anxiety, impacts performance in a dynamic C2 task.

Real-time monitoring of compensatory effort in response to stress could identify susceptibility to declines in performance. As stated in PET (Eysenck & Calvo, 1992), inefficiency of processing may not coincide with declines in performance due to the effortful maintenence of performance levels, but with added stress this compensatory effort may fail. Both EEG and electrocardiac indices have been used to monitor workload and effort, although controversy remains over the validity of the different available indices (Hockey, Nickel, Roberts & Roberts, 2009). Similarly, observation of stress and anxiety in real-time could drive automated systems meant to assist operators performing in circumstances of high stress or anxiety. These systems would function to alert operators of dangerous stress levels and allow them to task share with teammates (Dixon et al., 2009).

Further research to investigate the potential effects of anxiety on team performance in mixed-anxiety teams is necessary. In light of defensive performance differences in mixed teams, it is unclear if team differences are due to the averaging across individual performance of high and low trait anxiety team members, or if it is an emergent quality of mixed teams. Additionally, as suggested by Guznov et al. (2010), task type might also be manipulated and tested for interactive effects with trait anxiety in a team. Research is also needed to discriminate team effects that relate to handling of task workload (e.g., if one team member's assignment is overly demanding), and team effects derived from social interaction (e.g., if one team member loses confidence in another team mate).

Conclusions

The present work provided both methodological and empirical contributions towards understanding the impact of anxiety factors on performance in C2 environments. The success of the mood induction in elevating state anxiety and distress, without lowering task engagement shows that the effects of anxiety on complex military tasks can be studied using experimental methods. In the anxious induction period and in the anxious mood block, negative affective states were observed, relative to subjective state reports obtained in other blocks of the studies. Not only was the technique successful, but its effects persisted through the experimental block. Further research is needed to establish whether elevated state anxiety is of any operational significance, although the study established that high trait anxiety is associated with a more defensive style of performance. Although some limitations were noted, including limited statistical power, the results of the present study are encouraging and suggest a need for further investigation of anxiety effects on attention in simulated military operations.

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Appendix A

Recruitment Flyer

Participants Needed for a Research Project at the Air Force Research Laboratory

The Air Force Research Laboratory at Wright Patterson Air Force Base is seeking men and women volunteers to participate in a research study. Participants in this study will conduct simulated air battles with another teammate. Interested persons must participate in a 1 hour screening session prior to the experiment to determine eligibility. Participants will be compensated for their time. If eligible for the study, participants will be scheduled for one—6 hour experimental session.

Requirements to Participate

- Must be a U.S. citizen
- Must be between 18 and 30 years of age
- Must have some college experience
- Must have 20/20 vision or corrected vision (glasses/contacts OK)
- Must have normal color vision, and normal hearing
- Must NOT have previously participated in the MATRIX study or any other DDD study at AFRL
- Must complete the 1 hour screening session prior to the experiment
- Must be available for one—6 hour experimental session

Participants will be compensated for all of their time.

For more details and information please send an email to:

Becky.brown@wpafb.af.mil OR AprilRose.Panganiban@wpafb.af.mil

You may also call Becky Brown @ 937-255-0884

Please include 1) your name, 2) a phone number where you can be reached, and 3) a list of the days you are available to participate.

Appendix B

Emotional Health Questionnaire

This is a short questionnaire designed to give us some ideas about your medical history. For each of the following questions, please indicate "yes" if you think the statement applies to you, and "no" if it does not. Your answers to these questions will remain confidential, and will not be shared with anyone else.

1. Have you ever been diagnosed with and/or treated for any of the following:
    - Bipolar I Disorder
    - Bipolar II Disorder
    - Panic Disorder
    - Major, life affecting Phobia (e.g. agoraphobia, arachnophobia, xenophobia, etc.)
    - Acute Stress Disorder
    - Generalized Anxiety Disorder

    Please circle: YES / NO

2. Have you ever been diagnosed with and/or treated for any of the following:

    - Social Anxiety Disorder (Social Phobia)
    - Obsessive-Compulsive Disorder
    - Posttraumatic Stress Disorder
    - Minor Phobia
    - Overanxious Disorder of Childhood
    - Any other Depressive Disorders
    - Any other Bipolar Disorders
    - Any other Mood Disorders
    - Any other Anxiety Disorders

    Please circle: YES / NO
    2a. If yes, briefly explain:
    ____
    ____
    ____

3. Have you been prescribed/taken any of the following types of medications in the last 3 years (please ***do not*** indicate which, if any, you have been prescribed/taken):
    - Any Selective Serotonin Reuptake Inhibitor (SSRI; e.g., Celexa, Lexapro, Luvox, Paxil, Prozac, Zoloft, etc.)
    - Any Monoamine Oxidase Inhibitor (MAOI; e.g., Aurorix, Marplan, Nardil, Parnate, etc.)
    - Any Tricyclic Antidepressants (e.g., Asendin, Elavil, Norpramin, Pamelor, Sinequan, Surmontil, Tofranil, Vivactil, etc.)
    - Any other anti-depressants (e.g., Desyrel, Effexor, Remeron, Serzone, Wellbutrin, etc.)
    - Any medications related to mood regulation (e.g., Haldol, Loxitane, Mellaril, Moban, Navane, Prolixin, Serentil, Stelazine, Thorazine, Trilafon, Depakene, Depakote, Eskalith, Lithobid, Lithonate, Lithotabs, etc.)
    - Any anti-anxiety medications (e.g., Ativan, BuSpar, Centrax, Lexapro, Librium, Serax, Tranxene, Valium, Xanax, etc.)

    Please circle: YES / NO
    3a. If yes, briefly explain:
    ____
    ____
    ____

Appendix C

STPI-Trait Questtionaire

SELF-ANALYSIS QUESTIONNAIRE

Directions: A number of statements that people have used to describe themselves are given below. Read each statement and then circle the appropriate value to the right of the statement to indicate how you *generally* feel. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to best describe how you *generally* feel.

	Almost Never	Sometimes	Often	Almost Always
1. I am a steady person	1	2	3	4
2. I am quick-tempered	1	2	3	4
3. I feel satisfied with myself	1	2	3	4
4. I have a fiery temper	1	2	3	4
5. I get in a state of tension or turmoil as I think over my recent concerns and interests	1	2	3	4
6. I am a hot headed person	1	2	3	4
7. I wish I could be as happy as others seem to be	1	2	3	4
8. I get angry when I'm slowed down by others' mistakes	1	2	3	4
9. I feel like a failure	1	2	3	4
10. I feel annoyed when I am not given recognition for doing good work	1	2	3	4
11. I feel nervous and restless	1	2	3	4
12. I fly off the handle	1	2	3	4
13. I am secure	1	2	3	4
14. When I get mad I say nasty things	1	2	3	4
15. I lack self-confidence	1	2	3	4
16. It makes me furious when I am criticized in front of others	1	2	3	4
17. I feel inadequate	1	2	3	4
18. When I get frustrated I feel like hitting someone	1	2	3	4
19. I worry too much over something that really does not matter	1	2	3	4
20. I feel infuriated when I do a good job and get a poor evaluation	1	2	3	4

Appendix D

DSSQ-3 state questionnaire

PRE-TASK QUESTIONNAIRE

Instructions. This questionnaire is concerned with your feelings and thoughts at the moment. Please answer **every** question, even if you find it difficult. Answer, as honestly as you can, what is true of **you**. Please do not choose a reply just because it seems like the 'right thing to say'. Your answers will be kept entirely confidential. Also, be sure to answer according to how you feel **AT THE MOMENT**. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

Before you start, please provide some general information about yourself.

Age............. (years) Sex. M F (Circle one)

Occupation..

If student, state your major..................................

Date today..................... Time of day now.............

For each statement, circle an answer from 0 to 4, so as to indicate how accurately it describes your feelings **AT THE MOMENT**.

Definitely false = 0, Somewhat false = 1,
Neither true nor false = 2, Somewhat true = 3, Definitely true = 4

1. I feel concerned about the impression I am making.	0	1	2	3	4
2. I feel relaxed.	0	1	2	3	4
3. The content of the task will be dull.	0	1	2	3	4
4. I am thinking about how other people might judge my performance.	0	1	2	3	4
5. I am determined to succeed on the task.	0	1	2	3	4
6. I feel tense.	0	1	2	3	4
7. I am worried about what other people think of me.	0	1	2	3	4
8. I am thinking about how I would feel if I were told how I performed	0	1	2	3	4
9. Generally, I feel in control of things.	0	1	2	3	4
10. I am reflecting about myself.	0	1	2	3	4
11. My attention will be directed towards the task.	0	1	2	3	4
12. I am thinking deeply about myself.	0	1	2	3	4
13. I feel energetic.	0	1	2	3	4
14. I am thinking about things that happened to me in the past	0	1	2	3	4
15. I am thinking about how other people might perform on this task	0	1	2	3	4
16. I am thinking about something that happened earlier today.	0	1	2	3	4
17. I expect that the task will be too difficult for me.	0	1	2	3	4
18. I will find it hard to keep my concentration on the task.	0	1	2	3	4
19. I am thinking about personal concerns and interests.	0	1	2	3	4
20. I feel confident about my performance.	0	1	2	3	4
21. I am examining my motives.	0	1	2	3	4
22. I can handle any difficulties I may encounter	0	1	2	3	4
23. I am thinking about how I have dealt with similar tasks in the past	0	1	2	3	4
24. I am reflecting on my reasons for doing the task	0	1	2	3	4
25. I am motivated to try hard at the task.	0	1	2	3	4
26. I am thinking about things important to me.	0	1	2	3	4
27. I feel uneasy.	0	1	2	3	4
28. I feel tired.	0	1	2	3	4
29. I feel that I cannot deal with the situation effectively.	0	1	2	3	4
30. I feel bored.	0	1	2	3	4

POST-TASK QUESTIONNAIRE

Instructions. This questionnaire is concerned with your feelings and thoughts while you were performing the task. Please answer **every** question, even if you find it difficult. Answer, as honestly as you can, what is true of **you**. Please do not choose a reply just because it seems like the 'right thing to say'. Your answers will be kept entirely confidential. Also, be sure to answer according to how you felt **WHILE PERFORMING THE TASK**. Don't just put down how you usually feel. You should try and work quite quickly: there is no need to think very hard about the answers. The first answer you think of is usually the best.

For each statement, circle an answer from 0 to 4, so as to indicate how accurately it describes your feelings **WHILE PERFORMING THE TASK**.

Definitely false = 0, Somewhat false = 1,
Neither true nor false = 2, Somewhat true = 3, Definitely true = 4

1. I felt concerned about the impression I am making.	0	1	2	3	4
2. I felt relaxed.	0	1	2	3	4
3. The content of the task was dull.	0	1	2	3	4
4. I thought about how other people might judge my performance	0	1	2	3	4
5. I was determined to succeed on the task.	0	1	2	3	4
6. I felt tense.	0	1	2	3	4
7. I was worried about what other people think of me.	0	1	2	3	4
8. I thought about how I would felt if I were told how I performed	0	1	2	3	4
9. Generally, I felt in control of things.	0	1	2	3	4
10. I reflected about myself.	0	1	2	3	4
11. My attention was directed towards the task.	0	1	2	3	4
12. I thought deeply about myself.	0	1	2	3	4
13. I felt energetic.	0	1	2	3	4
14. I thought about things that happened to me in the past	0	1	2	3	4
15. I thought about how other people might perform on this task	0	1	2	3	4
16. I thought about something that happened earlier today.	0	1	2	3	4
17. I found the task was too difficult for me.	0	1	2	3	4
18. I found it hard to keep my concentration on the task.	0	1	2	3	4
19. I thought about personal concerns and interests.	0	1	2	3	4
20. I felt confident about my performance.	0	1	2	3	4
21. I examined my motives.	0	1	2	3	4
22. I felt like I could handle any difficulties I encountered	0	1	2	3	4
23. I thought about how I have dealt with similar tasks in the past	0	1	2	3	4
24. I reflected on my reasons for doing the task	0	1	2	3	4
25. I was motivated to try hard at the task.	0	1	2	3	4
26. I thought about things important to me.	0	1	2	3	4
27. I felt uneasy.	0	1	2	3	4
28. I felt tired.	0	1	2	3	4
29. I felt that I could not deal with the situation effectively.	0	1	2	3	4
30. I felt bored.	0	1	2	3	4

Appendix E

NASA-TLX

Next, please consider the demands of the decision-making task, and your reactions to the task. Please answer each of the following questions by circling a number from 0 to 10.

16. Please rate the MENTAL DEMAND of the task: How much mental and perceptual activity was required?

Low 0 1 2 3 4 5 6 7 8 9 10 High

17. Please rate the PHYSICAL DEMAND of the task: How much physical activity was required?

Low 0 1 2 3 4 5 6 7 8 9 10 High

18. Please rate the TEMPORAL DEMAND of the task: How much time pressure did you feel due to the pace at which the task elements occurred?

Low 0 1 2 3 4 5 6 7 8 9 10 High

19. Please rate your PERFORMANCE: How successful do you think you were in accomplishing the goals of the task?

Low 0 1 2 3 4 5 6 7 8 9 10 High

20. Please rate your EFFORT: How hard did you have to work (mentally and physically) to accomplish your level of performance?

Low 0 1 2 3 4 5 6 7 8 9 10 High

21. Please rate your FRUSTRATION: How discouraged, irritated, stressed and annoyed did you feel during the task?

Low 0 1 2 3 4 5 6 7 8 9 10 High

Appendix F

Vignettes and music for mood induction

Neutral Mood Induction

Music

Chopin waltzes, #s 11 and 12.

Vignettes

1. You get up in the morning, get dressed and have your usual breakfast.

2. You go to a restaurant and order a starter and a main course. You have a glass of water with your meal.

3. You go to the supermarket and get a weeks shopping. You unload the bags from the car and put the shopping away.

4. Whilst going for a walk you meet someone you know. You chat about the weather and your plans for the weekend.

5. You and some friends go to your local cinema and watch a film. After it is finished you go home.

6. As you are driving you notice you are low on gas. You fill up your car from a nearby gas station and buy a drink while you are there.

7. It is the evening and you are feeling tired. You have a long bath, wash your hair and watch some television.

8. You turn on your computer, load up a word-processing program and begin to type. You type up your essay and print it out, ready to be handed in.

Happy Mood Induction

Music

1. Delibes (1870). Mazurka from Coppelia

2. Bach (1721). Brandenburg Concerto #2

Vignettes

1. You just got a new job, and it’s even better than you expected.

2. You wake up on a Saturday after a number of wintry-cold rainy days, and the temperature is in the high sixties.

3. You buy a lottery ticket and you win $100.00 instantly.

4. You and a friend go to a nice restaurant. The meal, the conversation, and the atmosphere are all perfect.

5. You get out of class or work early. It’s a beautiful day and you and some friends go for an ice cream.

6. You spend a day in the mountains; the air is clean and sharp, the day sunny, and you take a swim in a beautiful lake.

7. You unexpectedly run into someone you like. You go for coffee and have a great conversation. You discover you think alike, and share many of the same interests.

8. It's your birthday and friends throw you a terrific surprise party.

Anxiety/Fear Mood Induction

Music

Ives (1906). Halloween.

Herrmann (1960). Psycho.

Vignettes

1. You are riding alone in an elevator when a man walks in and pulls out a knife. He stares at you without saying what he wants.

2. You're in an overcrowded carriage at the top of a ferris wheel when the mechanism malfunctions and the wheel jams. A thunder storm is developing, and the wheel sways in the wind, its metal creaking.

3. Your car breaks down on a back street in the dangerous part of the city. You start to go for help when you see several teenage boys walking toward you carrying weapons.

4. You are driving down an unfamiliar road on a stormy night when your car skids out of control.

5. You are driving down the road when a tractor trailer going in the opposite direction crosses over into your lane.

6. You're in your bedroom late at night when you hear someone enter your apartment. No one else you know has a key.

7. You're swimming in a dark lake and something big, slimy, and prickly brushes against your leg.

8. You're having a nightmare about someone chasing you and you fall into a bottomless pit. You start to scream in your sleep.