The Effects of Stress and Mood on Cognitive Performance

by

Maria Elena Gomez-Herbert

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Graduate Supervisory Committee:

Nancy Cooke, Chair
Lawrence Thacker
Hyunjin Song
David Becker
Russell Branaghan

ARIZONA STATE UNIVERSITY

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ABSTRACT

When discussing human factors and performance, researchers recognize stress as a factor, but overlook mood as contributing factor. To explore the relationship between mood, stress and cognitive performance, a field study was conducted involving fire fighters engaged in a fire response simulation. Firefighter participants completed a stress questionnaire, an emotional state questionnaire, and a cognitive task. Stress and cognitive task performance scores were examined before and after the firefighting simulation for individual cognitive performance depreciation caused by stress or mood. They study revealed that existing stress was a reliable predictor of the pre-simulation cognitive task score, that, as mood becomes more positive, perceived stress scores decrease, and that negative mood and pre-simulation stress are also positively and significantly correlated.

DEDICATION

To my three beautiful children, Elena, Gianna, and Samuel. May you always seek to expand your knowledge.

To the firefighters and police officers who risk their lives everyday to serve and protect.

To my military brethren, I am truly honored and privileged to serve along side you.

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The Effects of Stress and Mood on Cognitive Performance

Stress has been recognized as physiological phenomena since the early 1900's. In 1908, Yerkes and Dodson diagramed an observed performance improvement with increasing stress followed by an abrupt decline in performance as stress or workload continued to increase past an optimal level and thus hypothesized that an optimum motivation level exists (Broadhurst, 1957, p.345) (Figure 1). Later, Selye discussed the implications of prolonged stress on physical and mental health. He called the phenomena General Adaptation Syndrome (Selye, 1957, 1384). However, in 1960 Denenberg noted that rats with a higher level of emotionality demonstrated more drive or motivation than non-emotional rats (Denenberg, 1960, p.429). Lazarus noted mood were often confounding factors in his stress and performance studies. He suggested that, unbeknownst to researchers, the terms emotion and stress were being used interchangeably. Until then, researchers recognized stress as a factor in human performance, studies but overlooked emotion as powerful mediators.

To explore the relationship between mood, stress and cognitive performance, the current field study looked at fire fighters in the context of a fire response simulation. Because the volunteers were all firefighters participating in a training simulation, they were not divided into different treatment conditions. Participants performed a number comparison perceptual speed cognitive task to objectively measure an aspect of individual cognitive performance before and after the simulation. Firefighters also completed mood and stress state questionnaires before and after the exercise. I hypothesized that individual cognitive performance would be worse at the end of the simulation compared to beginning and that the participant's mood will compound the negative effect of stress on performance.

The resulting scores on individual and team measures were to provide insight into whether performance declines or not throughout the high-stress conditions and if mood indeed plays a role along side stress or over and above stress on individual cognitive performance. The overall objective was to determine the roles that stress and mood play independently or in

combination to impact cognitive performance. The study was motivated by the dearth of mood factors cited in human performance studies and in mishap investigations where human factors are identified as causal.

Disaster and Mishap Investigations. Civilian and military mishap investigators work to identify the myriad of industrial, organizational or human factors that contributed to the mishap or accident in order to prevent others from happening. For example, members of an Air Force Safety Investigation Board explore organizational, cultural, mission related, maintenance and physical, physiological and psychological human factors (Air Force Instruction 91-904, Safety Investigations & Reports, 2008). The psychological human factors may include perceived institutional pressures, personal and work related stress, chronic and acute fatigue and their effects on performance such as ineffective communication, confusion, and flawed risk assessment and decisions. Despite investigators' best efforts, teasing out a single root human factor cause of a mishap can prove elusive. This may be due to the fact that neither civilian nor military mishap investigation teams address the role of emotions, or mood in these extreme examples of human performance failures.

The review of literature that follows looks into some of the existing work in stress, cognitive performance and mood research.

Stress. Yerkes and Dodson's work at the turn of the 20th century explored the relationship between strength of stimulus (threat of electrical shock – demand) and task acquisition (choosing the right box – performance) in mice and from her was, extrapolated to other animals, most notably humans (Le Fevre, 2003, p. 729). Their findings indicated an optimal point and a point of diminishing returns where as the stimulus increased, performance decreased. The inverted U of the Yerkes-Dodson diagram illustrates this relationship with stimulus on the horizontal axis and performance on the vertical. Nearly 50 years later, Selye's work defined stress as an inevitable consequence of living (Selye, 1957). He asserted that the demand stimulus might be perceived as pleasant or unpleasant—as eustress or distress. Blood pressure for instance, applies physical stress to blood vessels. An optimal amount of blood pressure ensures adequate perfusion to the organs and periphery. Low pressure, however, leads to lethargy and circulatory problems whereas high blood pressure contributes to cardiovascular disease. Thus, blood pressure outside the optimal range causes distress on the system.

Something similar occurs when psychological demands exceed a person's ability to manage those demands (Selye, 1957). In Selye's treatment of distress, the degree of demand is fundamental, further validating the relationship illustrated by Yerkes and Dodson's observations (Le Fevre, 2003, p.279). Later, Broadhurst (1957) and Denenberg and Karas (1960) pointed out how emotionality affects performance, but did not differentiate between 'emotionality' and stress in their work (Broadhurst, 1957; Denenberg, 1960). In the 1960's and 70's Lazarus defined stress in terms of how an individual appraises demands in his or her environment (Matthews, 2001, p.7). He explains the relationship between a person and demands does not depend on the demands alone, but how well the person feels equipped to handle, or survive, the demands. If he or she appraises the relationship as a threat to their well being—either real, as a physical threat, or perceived, as a psychological threat—and exceeding his or her resources then distress occurs. Thus, Lazarus declared stress was a transaction between an individual and demands

upon that person that involves an appraisal. The central tenet of Lazarus' Transactional Theory was that stress resulted from a person's active attempts to deal with external demands and that person's perception, or appraisal, of their own ability to meet those demands (Matthews, 2001, p.7; Pfaff, 2012, p.561). These appraisals often inevitably involve feelings about the appraisal. Specifically, a person's cognition about a demand is inseparable from the emotional and physiological reactions simultaneously elicited by their appraisal of the situation (Lazarus, 1991, p.353). The resulting complicated cognition-mood relationship makes distinguishing between stress and mood in performance research complicated, and all the more necessary if we are to understand the effects of each. Lazarus (1991) warned that stress and mood may often be treated as indiscriminate factors when scientists use stress as a catch-all term for psychological or emotional phenomena or attribute all deleterious effects on performance to stress alone (Stokes & Kite, p.110, 2002). He recommended stress and mood be studied together and be partialed out from each other in analysis. This study will specifically look for possible interactions between mood and stress states in terms of their joint impact on individual cognitive resources (Pfaff, 2012, p. 562). First, a clarification about the terms feelings, emotions and mood is necessary. Feelings, emotions and mood are treated here as a continuum of persistence. Whereas a feeling is immediate and synonymous with an emotion, mood refers to a more persistent emotional state. Emotions and feelings sustained over time constitute a specific mood. In this study, the experimenter asked participants to report their various feelings over the recent past and, thus, collected mood information.

Cognitive Resources, Stress and Mood. Attentional or cognitive resources can be looked at as a pool of attentional resources to be judiciously partitioned among various cues at once with varying degrees of attention allocated to each one (Matthews, 2001, p.11). Cognitive resources reflect the capacity to direct and focus attention. Cognitive performance, on the other hand, refers to how well one attends to relevant cues, manages distractions, makes decisions and accesses information from short-term memory (STM) for use in working memory (WM). In other

words, cognitive performance reflects attentional control or how well one distributes attention. Moreover, due to the high correlation of cognitive performance with WM, it can be gauged with WM measures (Engle, 2002, p.19). Under the transactional theory of stress, allocation of cognitive and attentional resources during stressful events can be categorized as either task-directed (task-focused) or internally directed (emotion-focused) (Engle, 2002, p.7; Lazarus, 1987, p. 147). For example, individuals who used task-focused or task-directed attention allocation directly address the stressor(s) and thereby regulate the problem causing the distress. Workload and stress decrease as a result (Weaver, et al, 2001, p. 85). Conversely, individuals who employ an emotion-focused or internally directed coping strategy regulate emotional responses to problems by redirecting significant amounts of cognitive energy away from the stressful task to managing the emotions about the task or event (ibid). Because the emotion-focused person uses cognitive resources to manage emotions instead of allocating them towards task completion, he or she experiences a higher workload and higher stress.

Just as an individual's stress level and mood affect their own cognition, one team member's performance affects a team's performance. Pfaff found that an individual's loss or narrowing of focus resulted in a loss of team awareness (Pfaff, 2012, p.562). Cooke, Salas, Kiekel and Bell observed that when the workload demands of the task in their study were increased, team performance, typically declined (Cooke, 2004, p.23). This could occur due because of failure to attend to relevant cues in one's own role or failure to share or obtain valuable information from the rest of the team. If an individual team member's mood and stress levels affect that person's attentional capacity through cognitive interference, then his or her poor performance can affect the entire team. In 2004 Offerman, et al. conducted a study to differentiate the effects of cognitive ability on individual tasks from the effects of emotional competency on team performance (p.220). He focused on team leader effectiveness and results indicated that when a key contributor of team interactions suffers, the entire team's cognition suffers, and performance of the entire team suffers.

Growing research in the field of Judgment and Decision Making confirms that emotions and mood alone affect judgment and decision-making through their influence on cognitive strategies (Mosier, 2010, p. 240). Gasper (2002) and Mosier (2010) demonstrated how a positive or happy mood leads to a more global or "Big Picture" attentional focus compared to the narrow or more detail-oriented focus demonstrated by participants in a negative or sad mood (Gasper, 2002; Mosier, 2010). Consequently, general mood can influence a person's attentional load especially during stressful and emotionally taxing events (Pfaff, 2012, p. 566). Sarason dubbed the conflict caused by the extra burden on cognitive resources cognitive-interference (Sarason, 1986).

Cognitive Interference. The phenomenon cognitive interference came from test anxiety research. Here the re-allocation of cognitive resources, specifically WM, from the task at hand to processing internal worries correlated with performance deficits (i.e. poorer test scores) (Matthews, 2001, p. 8). Worry, better known as performance anxiety, resulted when a person assessed their available resources and ability to succeed, versus the demands of the task and appraised their chance for success as low. By the above definition, cognitive interference results from mood-focused or internally directed coping strategies. Thus, cognitive interference due to mood-focused coping could explain why some individuals demonstrate performance depreciation and others do not even under comparably stressful circumstances. The stress, mood and performance relationship remains complicated and continues to provide fodder for human performance studies. The more recent work done by Lazarus (1999) and Pfaff (2012) suggested mood might in part explain why even though stress initially serves as a motivator, after an optimal performance "sweet-spot" performance markedly decreases in a parabolic fashion (Goleman, 2013, "Sweet Spot for Achievement," Psychology Today, Accessed 1 March 2013). As of now, when it comes to explaining the stress-motivation-performance dynamics, there seems to be no reliable model to predict at what point stress depreciates and ceases to motivate

performance. This study used established measures of stress, mood and cognitive performance to help shed some light on the potential connections.

Measures of Stress and Mood. For this study, stress levels at the beginning and the conclusion of the fire fighting simulation were assessed via the Perceived Stress Questionnaire (PSQ) developed by Levenstein et al (1993). The PSQ was chosen from among several validated stress scales such as The Daily Stress Inventory (DSI) and the Hassles and Uplifts Scales ((Brantley, et al, 1988; Brantley, 1985; Kanner, 1981). The PSQ asks 30 brief questions (compared to the DSI that has a total of 60 questions with three requiring open-ended responses). PSQ questions are simple and correlate strongly with physiological stress markers, as well as individual's self-assessments of personal stress (Levenstein, 1992, p. 26). According to Levenstein, the PSQ demonstrated high internal consistency, high reliability, and validity.

The current experiment used the same emotional state questionnaire used in the Pfaff study, the Positive and Negative Affective Scale (PANAS). The PANAS is a 20-item questionnaire developed to efficiently and accurately capture positive and negative mood information (Watson, 1988). The scale was validated to capture immediate or long-term mood state based on the specific instructions given the participant. For example participants can be instructed to indicate the extent to which they were in a certain mood as recently as that moment to as long ago as a year. The scale's brevity makes it an ideal tool for the purpose of assessing mood state in this study. The PANAS demonstrated sound test-retest reliability across the different time intervals (moment, day, weeks, etc.) and correlated well with other measures of anxiety, depression and general mood (Watson, 1988, p. 1068)

Measures of Cognitive Function. Different cognitive tasks test different aspects of executive control of working memory (WM). WM is considered two things: a key component of cognitive performance and a direct reflection of executive control (Engle, 2002; Fan et al, 2002). Executive control or executive attention refers to the ability to control or allocate attention adequately to appropriate cues; the ability to resolve conflict between several attention-seeking

cues and stay on task despite distractions (Engle, 2002; Fan, et al, 2002). The collection of cognitive tasks includes different versions of the Digit Span, Flanker (Eriksen & Eriksen, 1974), and Perceptual Speed (Redick, 2012) tasks. Together they test inter-related dimensions of executive control and WM. The Digit Span task for instance tests the short-term memory (STM) component of (WM). During the Digit Span task, participants are momentarily shown a string of alpha or numeric digits and then attempt to recall them in the specified order (Engle, p.21, 2002). The Flanker task measures the ability to correctly identify a target amongst distractors flanking it (<<<>+<<< or +++++---). The Perceptual Speed tasks test WM by asking participants to identify a target in a limited amount of time. Participants normally perform several cognitive tasks in one study and the scores together provide an objective measure of individual cognitive performance. Due to the constraints of the fast-paced, brief simulation training used in this experiment, only one cognitive task was chosen.

In 2002, Ackerman conducted a study in an attempt to irrevocably identify the connection between WM and perceptual speed (PS) noting that many tests of general intelligence via WM measures involved a speed element (Ackerman, 2002). Specifically, perceptual speed shares some variance with WM (r = .47). Furthermore, the performance on a PS task depends not only on the difficulty of the timed task—the more complicated, the more time the task takes to complete and the more accuracy suffers—but perceived difficulty of the task increases as stress increases. This aspect of the assessment is of particular interest in a study looking for the connection between a stress and individual performance under time pressure. In this cognitive task participants identify identical or mismatched number pairs. Number comparison focuses not only on the number of correct answers, but also on how quickly and accurately multiple questions are answered in the given amount of time (Ackerman, 2002, p. 570). Participants performed the cognitive tasks twice on a Casio G-Zone smartphone: once at the before the beginning of the simulation and again upon completing the emergency scenario. The results were assessed for a significant pre and post-test difference in scores. Operationalizing cognitive tasks

for the field may provide insight about incident team members' the ability to allocate attention, ignore distractions, and make decisions during continuous emergency response operations.

Crisis Management Teams. Crisis management teams consist of emergency response professionals working together during a natural or man-made disaster. Teams are composed depending on the severity of the situation. They may include local, state or federal level fire department, police force, medical, and/or military personnel. Incident Command and Control (ICC) teams, the executive command and control element of crisis management response, perform the complex, highly interdependent tasks of coordinating policing, fire suppression, medical response, and search and rescue operations under highly stressful conditions (Salas & Cannon-Bowers, 2001, p.83). The success and safety of the first responders and civilians responding to the scene hinges on their ability to maintain focus, communicate effectively, manage risk, and make sound decisions under pressure. Hence, the effects of stress and mood on crisis team member's performance especially deserve study.

In 1996 Flinn investigated the decision-making performance of emergency response and offshore oil and gas teams to various emergencies like fires, explosions, and blowouts in the aftermath of the Piper Alpha and Ocean Odyssey ocean oil rig mishaps (Weaver, 2001, p.90). She noted the negative effects of chronic and acute stress that contributed to the mishaps. The effects ranged from aggressiveness, irritation, and apathy to tunnel vision, reduced concentration, and distorted time perception, as well acting hastily with over-reliance on familiar response sets, and lack of proactive response planning (Weaver, 2001, p.90). She observed these effects on individual team members who, in turn, affected team dynamics. Exploring the role of mood on performance can elucidate why some individuals or teams thrive and other teams fail under comparably stressful conditions.

Lazarus (1987) correctly asserted that mood and stress are interrelated dimensions of the human experience influencing performance. In Pfaff's directly study on the effects of mood on team awareness, he split participants into either of two conditions--no stress or high stress

(Pfaff, 2012, p.564). All groups were to participate in the same computer based crisis management simulation. He used time pressure to elicit the high stress condition. Groups then watched either a sad or happy video clip to induce the corresponding negative or positive mood before the computer simulation. Pfaff verified that emotional state, or mood, plays a significant role in performance. Specifically, positive mood enhanced team awareness, whereas the sad mood reduced it independent of stress (Pfaff, 2012, p.566). Armed with this knowledge, human performance researchers and mishap investigators now have another dimension for understanding human performance and team performance failures. Eventually, mood or mood may become a distinct human factors category to research and investigate. Pfaff contends that mood is omitted or understudied in the first responder and military communities because those cultures suppress or invalidate the effects of mood separate and apart from stress (Pfaff, 2012, p.563). Simulations offer an effective and safe platform for studying the role of mood on performance.

Incident Response Simulation. The Virtual Incident Command Center (VICC) fire response simulation provided the high workload, task saturating, and high attentional load environmental context for the study. The firefighting scenario included time pressure and multiple events happening simultaneously. Participation in the fire simulation allowed firefighters to perform job related tasks under high-workload and timed conditions safely and provide cognitive performance, mood and stress data for analysis.

Hypotheses. Based on stress and performance literature, stress will supposedly enhance performance up to a point. According to Pfaff's 2012 study findings, emotion, specifically negative emotion, will exaggerate the adverse effects of stress. Therefore, this study was modeled after Pfaff's study, which used a brief computer simulation, stressful conditions along with negative or positive mood to explore the effects of mood on team awareness. The experimenter used a cognitive performance task, a stress questionnaire and an emotional state

questionnaire to measure those parameters before and after a 15-20 minute firefighting simulation.

Hypothesis 1: Individual cognitive performance will markedly depreciate from an initial measurement after participants complete a high stress firefighting simulation.

Hypothesis 2: Negative mood will negatively influence cognitive performance over and above stress.

METHOD

Participants

Participants were 17 male firefighters from Maricopa County Arizona with minimum seven to ten years of experience preparing for their Fire Captain's qualification examination and who were familiar in team lead responsibilities. A convenience sample of experienced firefighters was studied to reduce participant inexperience and to increase validity of findings to the first responder, high-risk operations population (firefighters, police officers, military personnel) (Denenberg, 1960, p. 430). Participants personally procured and paid for Sets and Reps training within the Virtual Incident Command Center (VICC) in preparation for an upcoming promotion test. Sets and Reps training consists of a full day where students simulate being the first on the scene of a fire scenario and act as team lead for 15-20 minutes at a time. Participants did not receive incentives or compensation for their participation. Even though students often returned to the VICC to repeat training, no one participant volunteered more than once.

Materials

Simulation Center. The study was conducted at Mesa Community College's Virtual Incident Command Center (VICC). The VICC is a virtual reality laboratory that provides an immersive environment for the study and practice of management and decision-making skills used by first responders during disaster response operations (Thacker personal communication, 2013). The facility contains several rooms for team interaction. Rooms include simulated emergency response vehicle cabins, mobile CRV, and eight isolation rooms to simulate on scene emergency responder actions and team interactions at the scene (ibid). The VICC Staff developed Sets and Reps training to give Firefighters and Company Officers an opportunity to polish their incident management skills through multiple simulations in a condensed time frame. Students gained exposure to multiple scenario types including houses, apartments, strip malls, and commercial buildings. A brief classroom discussion and critique-focused lessons learned from each simulation followed each scenario.

Smart Phones. During the study, participants primarily used Casio G'Zone Commando ™ and, occasionally, iPhone 4 and 5s to access and complete the web-based cognitive tasks. The smart phones accessed the Internet via the Mesa Community College Wi-Fi network. iPhones were used because the Casio cell phones often dropped the Wi-Fi signal. Participants were all familiar with smart phones.

Procedure

Firefighters were notified of the study in the email reminder of their upcoming training. Reminder email included the link to cognitive tests, informed consent, and a brief description of the study. At the beginning of the training day, the experimenter briefed participants again on the study and stressed the volunteer nature of participation before collecting informed consent. VICC instructors described the roles and responsibilities of the on-scene team lead. The job of the first officer on the scene or team lead is to coordinate the activities of the various fire-fighting resources responding to the fire. Those resources include fire engines, ladder trucks, and firefighting teams distributed inside and outside the building. The team lead must rapidly coordinate response to various situations such as changing fire behavior, malfunctioning equipment and other unexpected events. When a student proceeded to the simulated fire SUV (Figure 2) to begin the scenario, the other students in the classroom simulated all the engines and ladders involved in the response outside of the fire response vehicle. The team lead received radio communications from virtual dispatch, as well as other first responders and firefighters at the scene. The Sets and Reps training included time pressure, high-workload, high-cognitive demand and high-stress similar to conditions students would face in a real world scenario. The experimenter ensured that the experimental procedure did not interfere with the students' training or performance during the simulation.

Volunteers completed the first Perceived Stress Questionnaire (PSQ) and Positive and Negative Affect Scale questionnaire (PANAS) at the beginning of class. This first PSQ provided

the pre-test stress measure and the PANAS responses provided overall mood information. The subjects completed one round of the number comparison cognitive task before entering the fire response vehicle. This test served as the pre-simulation cognitive function measure. The test's number strings varied in length from three to 5 or 7 digits to induce increasing complexity (Figure 3) and the test took approximately two minutes to complete. The participant then completed the 15 to 20 minute simulation. After the scenario, participants filled out one more PSQ and took one number comparison test. Both the stress and cognitive function measures served as post-test assessments of stress and cognitive function.

RESULTS

Relationships between PSQ and PANAS and the number comparison tasks were analyzed for correlations and predictive relationships using Statistical Package for the Social Sciences (SPSS). Alpha levels for significance was set to $p < .10$ to accommodate for a small sample size (n = 17). Several relationships reached significance. Raw data consisted of participants' scores on the PSQ, PANAS and perceptual speed number comparison task with two participants' measurements of pre and post simulation task scores deleted via listwise deletion because responses were lost. Data were therefore analyzed for the remaining 15 participants. A high score on the PSQ signified a high level of perceived stress. The PANAS scores included separate positive and negative mood scores and a composite score formed by subtracting the negative score from the positive score. For instance, for a participant with a positive mood score of 35 and a negative mood score of 15, the overall mood score for that person was net 20 and overall positive. Finally, for a participant with a positive mood score of 30 and negative mood score of 20, the overall mood score would still be positive, but less so than the other scores.

Pre-Simulation Stress (M = 66.4, SD = 7.327) and Pre-Simulation Task (M = 30, SD = 6.514), were significantly correlated (p = .006*, r = .676;Table 2) such that higher levels of stress were associated with higher levels of performance. A regression analysis of the data discovered a significant regression coefficient for pre-simulation stress (Beta = .601; p = .006; CI [.209 -- .994]) (Figure 9). Existing stress was a reliable predictor of the pre-simulation cognitive task score for this sample.

The relationship between pre-simulation stress (M = 66.4, SD = 7.327) and mood (M = 22.733, SD = 11.398) was of interest because mood has been recognized but understudied as a confounding factor in performance and stress measures (Figure 8). This relationship proved significant (p = .080*; r = -.466). The shared variance between pre-simulation stress and mood (-38.957) show that, as mood becomes more positive, perceived stress scores decrease (Table

2). Negative mood and pre-simulation stress are also positively and significantly correlated (r = .516, p = .049*).

The next relationship of interest probed involved mood (M = 22.733, SD = 11.398) and initial cognitive task score (M = 30, SD = 6.514) (Table 2). Mood and initial cognitive task scores were negatively correlated (r = -.330) but not significantly so (p = .230). Furthermore, mood was not shown to contribute significantly to cognitive performance either independently or above and beyond stress in this study. Negative mood (M = 17.67, SD = 6.466), on the other hand, does seem to be related to the cognitive score (r = .516, p = .049). Unexpectedly, higher levels of negative mood are associated with higher levels of performance on the pre-simulation task. This relationship could be due to the positive linear relationship between stress and negative emotion (Figure 7). As noted in Pfaff's study, negative emotion leads to a detail oriented focus and in a simulation in which firefighters must pay attention and address several issues at once, this may combine with the initial enhancement effect stress has on performance.

DISCUSSION

This study did not support the hypotheses that individual cognitive performance will markedly depreciate from an initial measure after students complete a high stress firefighting simulation, nor that negative mood will negatively influence cognitive performance over and above stress. Several aspects of this study could lead to a failure to capture any of the predicted effects. First, the simulation environment far removed from physical hazards may fail to elicit the same sense of urgency or stress professional firefighters experience when they respond to a real-world fire. Alternatively, professional firefighters may genuinely thrive under pressure and their performance enhanced by the perceived challenge instead. Second, because of the nature of this field based experiment no aspect of firefighter mood or stress level was manipulated in the study. Participants were surveyed for their existing subjective stress and emotional state. Negative mood scores stayed within a narrow range and, generally, participants reported overall positive mood with a very low negative mood component. All of them reported moderate to moderately high stress levels. Additionally, types of stress experienced at the two measurement times, might have been different. Participants likely experienced performance anxiety in anticipation of the exercise and experienced a mixture of performance related stress and relief after the simulation. Finally, the low number of participants affected the experiment's power. G-Power® estimated 64 participants were required to achieve .3 effect size, and .8 power with an $\alpha < .10$ and this study only included 17 participants total.

In conclusion, even though the findings in this study did not immediately support the hypotheses that performance would decline with increased stress and negative emotion would enhance the effect of stress, the effects might have been more salient with a larger sample size and a longer simulation. The roles of stress as a performance enhancer and of negative emotion as enhancing detail-oriented focus, however, are reflected in the results.

CONCLUSION

An experiment that includes distinct emotional and stress conditions during an extended simulation with members of the fire service, police and military community could lead to a reliable model of cognitive performance behavior during high-stress conditions. If correlations and relationships were confirmed, the model could influence shift duration policy for crisis management teams. Under current guidelines, ICC team members work 12-hour or longer shifts during which they perform critical tasks and make high-stakes decisions. If a body of research reliably demonstrated a definitive decline in cognitive performance, policy may change to reflect the need for shorter shifts or higher personnel turnover. Equally important, understanding the influence of mood on cognitive performance can help individuals understand their predispositions for cognitive vulnerabilities and know when to employ a mediating strategy.

Another area in which this could be applied is during mission planning and risk assessment. Air Force schedulers conduct a risk assessment during mission planning and when deciding crew composition. Crewmembers—pilot, co-pilot, and additional aircrew—then conduct their own risk assessment. Aside from mission specific factors—length, time and type of mission, crew composition, type of cargo and critical points—the crews answer general questions about their individual risk factors. Currently, under the category "Health and Stress Risk Factors" the questions are few in number and superficial in nature. Aircrew must assess Personal Health Factors (such as hydration, nutrition, illness/injury, etc.), Personal/Financial Stress (health, finance, relationship, etc.), and Work/Career Stress and Perceived Mission Pressure (internal and external) using a simple Low, Moderate and High scale. However, at this time the Personal Health Factors and Personal Stress Factors section makes no mention of emotional state or mood. Even though the results of this particular experiment did not confirm the relationship among stress, mood, and performance, the strong linear relationships between stress, negative emotion and performance demonstrated the strength of the emerging associations and deserves further study.

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APPENDIX A

TABLES

Table 1

Means and Standard Deviations, N=15

	Mean	Std. Deviation	N
Task_pre	30.0000	6.51372	15
Task_post	31.4000	4.74793	15
PSQ_pre	66.4000	7.32705	15
PSQ_post	69.7333	11.44844	15
Mood	22.7333	11.39841	15
Mood_Pos	40.40	8.296	15
Mood_Neg	17.67	6.466	15

Table 2
Pearson Correlations, df=13.
*$p < .10$

	Task_Pre	Task_Post	Stress_Pre	Stress_Post	Mood	Mood_Pos	Mood_Neg
Task_Pre Pearson Correlation	1						
Sig. (2-Tailed)							
Covariance	42.429						
Task_Post Pearson Correlation	.795	1					
Sig. (2-Tailed)	.000*						
Covariance	24.571	22.543					
Stress_Pre Pearson Correlation	.676	.529	1				
Sig. (2-Tailed)	.006*	.043*					
Covariance	32.286	18.400	53.686				
Stress_post Pearson Correlation	.509	.228	.764	1			
Sig. (2-Tailed)	.053*	.414	.001*				
Covariance	37.929	12.4	64.114	131.067			
Mood Pearson Correlation	-.330	-.123	-.466	-.494	1		
Sig. (2-Tailed)	.230	.662	.080*	.061*			
Covariance	-24.500	-6.671	-38.957	-64.433	129.924		
Mood_Pos Pearson Correlation	-.052	-.112	-.251	-.306	.830	1	
Sig. (2-Tailed)	.855	.692	.367	.267	.000*		
Covariance	-2.786	4.400	-15.243	-29.100	78.471	68.829	
Mood_Neg Pearson Correlation	.516	.361	.501	.477	-.698	-.180	1
Sig. (2-Tailed)	.049*	.187	.057*	.072*	.004*	.521	
Covariance	21.714	11.071	23.714	35.33	-51.452	-9.643	41.810

Table 3.

Regression Models

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.676[a]	.458	.416	4.97822	.458	10.968	1	13	.006*
2	.707[b]	.499	.416	4.97793	.042	1.002	1	12	.337

a. Predictors: (Constant), PSQ_pre

b. Predictors: (Constant), PSQ_pre, Mood_Neg

c. Dependent Variable: Task_pre

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta	Std. Error			Lower Bound	Upper Bound
1	(Constant)	-9.932	12.126			-.819	.427	-36.128	16.264
	PSQ_pre	.601	.182	.676	.204	3.312	.006	.209	.994
2	(Constant)	-7.158	12.438			-.575	.576	-34.257	19.942
	PSQ_pre	.496	.210	.558	.236	2.366	.036*	.039	.953
	Mood_Neg	.238	.238	.236	.236	1.001	.337	-.280	.756

a. Dependent Variable: Task_pre

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.227[a]	.052	-.012	4.67561	.052	.816	1	15	.381
2	.318[b]	.101	-.028	4.71234	.049	.767	1	14	.396

a. Predictors: (Constant), PSQ_post

b. Predictors: (Constant), PSQ_post, Mood_Neg

c. Dependent Variable: Task_post

Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients		t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta	Std. Error			Lower Bound	Upper Bound
1	(Constant)	25.480	7.177			3.550	.003	10.182	40.777
	PSQ_post	.092	.101	.227	.251	.903	.381	-.125	.308
2	(Constant)	25.096	7.247			3.463	.004	9.553	40.638
	PSQ_post	.051	.112	.127	.278	.457	.655	-.189	.292
	Mood_Neg	.185	.211	.244	.278	.876	.396	-.268	.638

a. Dependent Variable: Task_post

APPENDIX B

FIGURES

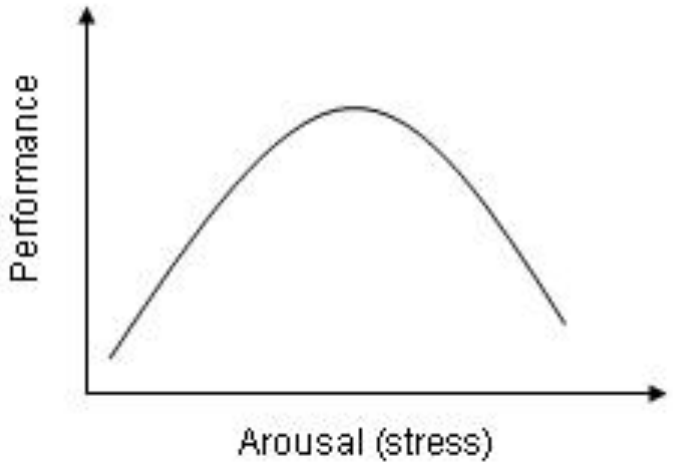


Figure 1. Yerkes Dodson Diagram

http://changingminds.org/images/yerkes.jpg, accessed 10 June 2014



Figure 2. Virtual Incident Command Center (VICC) Simulated Response Vehicle

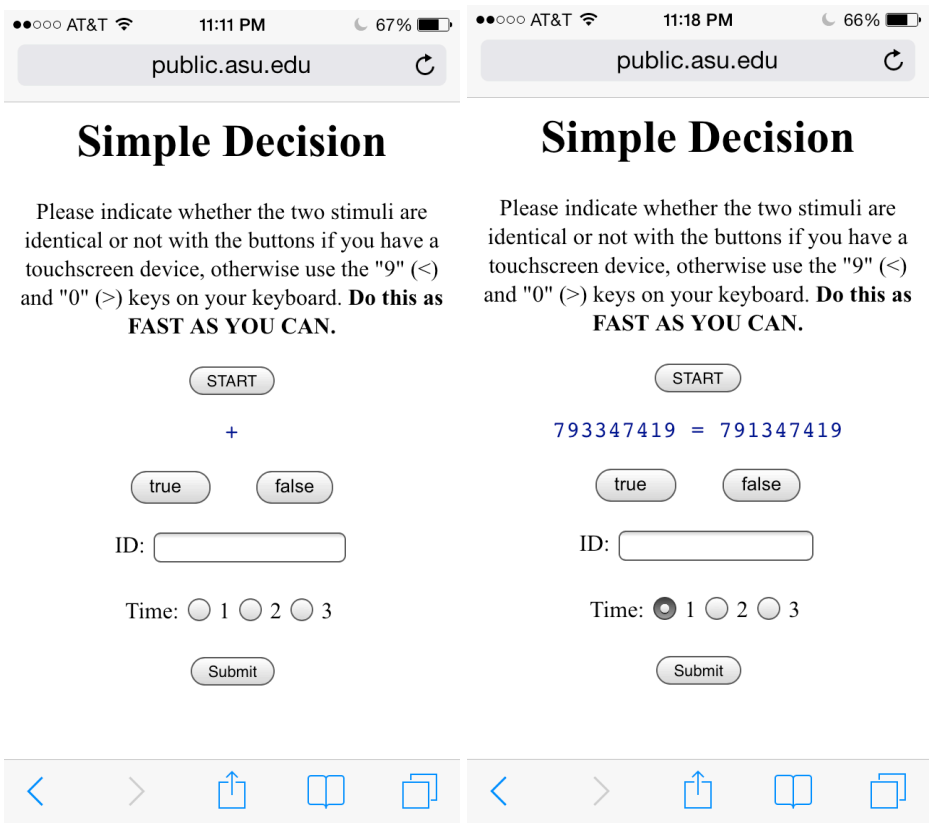


Figure 3. Perceptual Speed Number Comparison Task

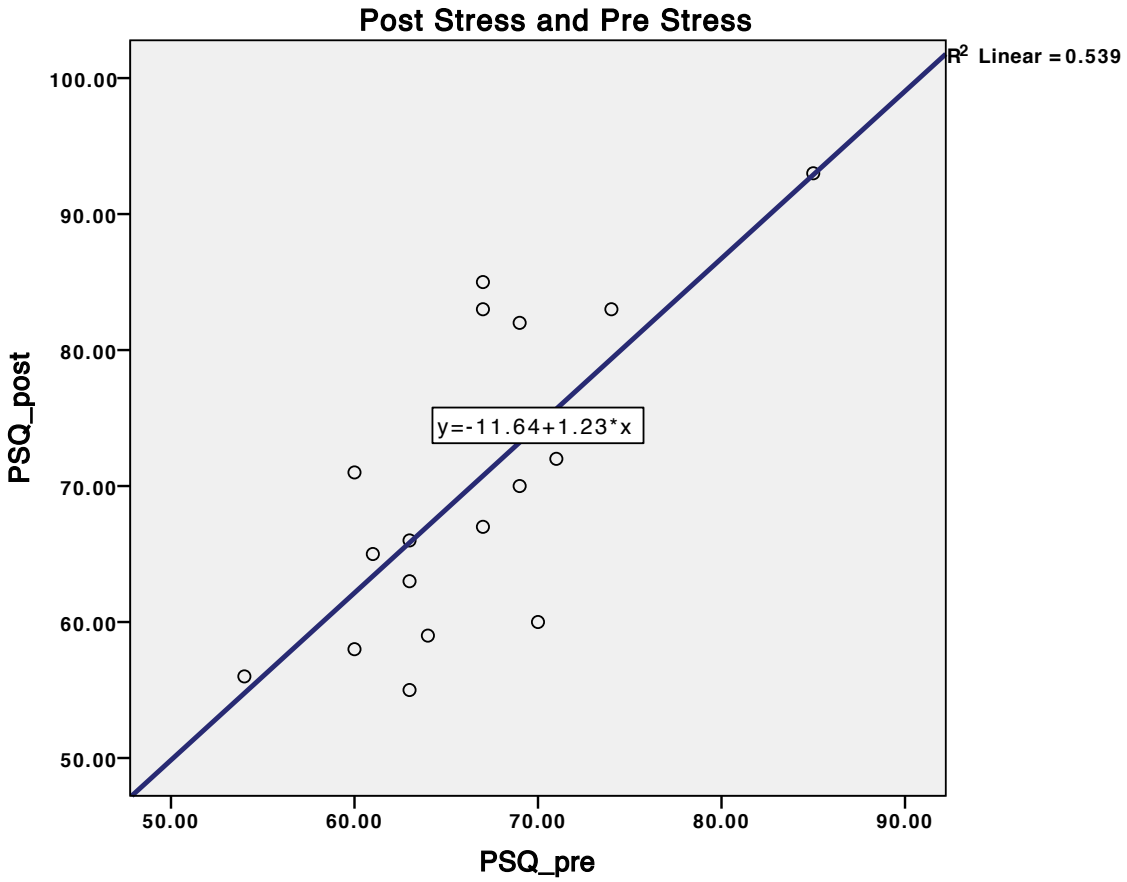


Figure 4. Pre and Post Simulation Stress Relationship

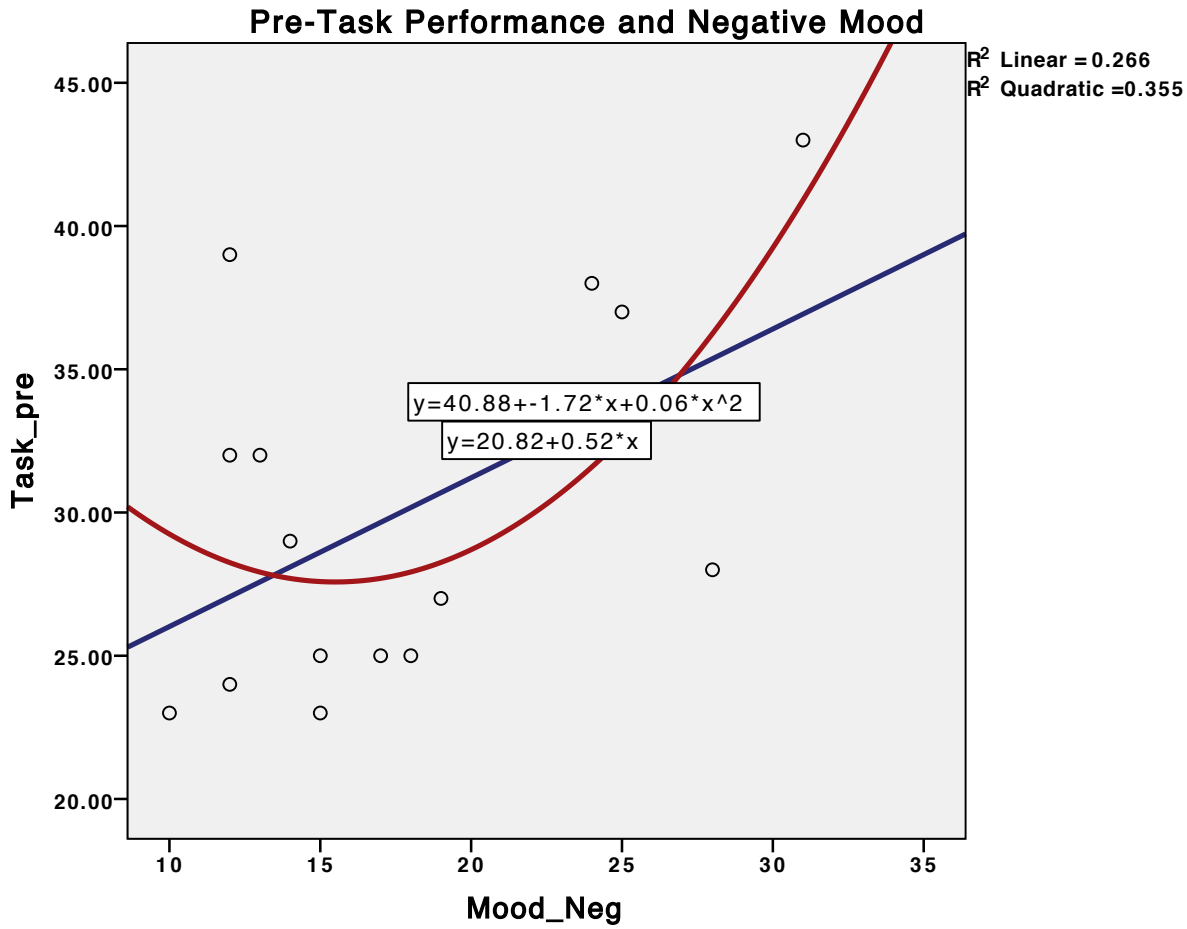


Figure 5. Pre-Simulation Task and Negative Mood Relationship

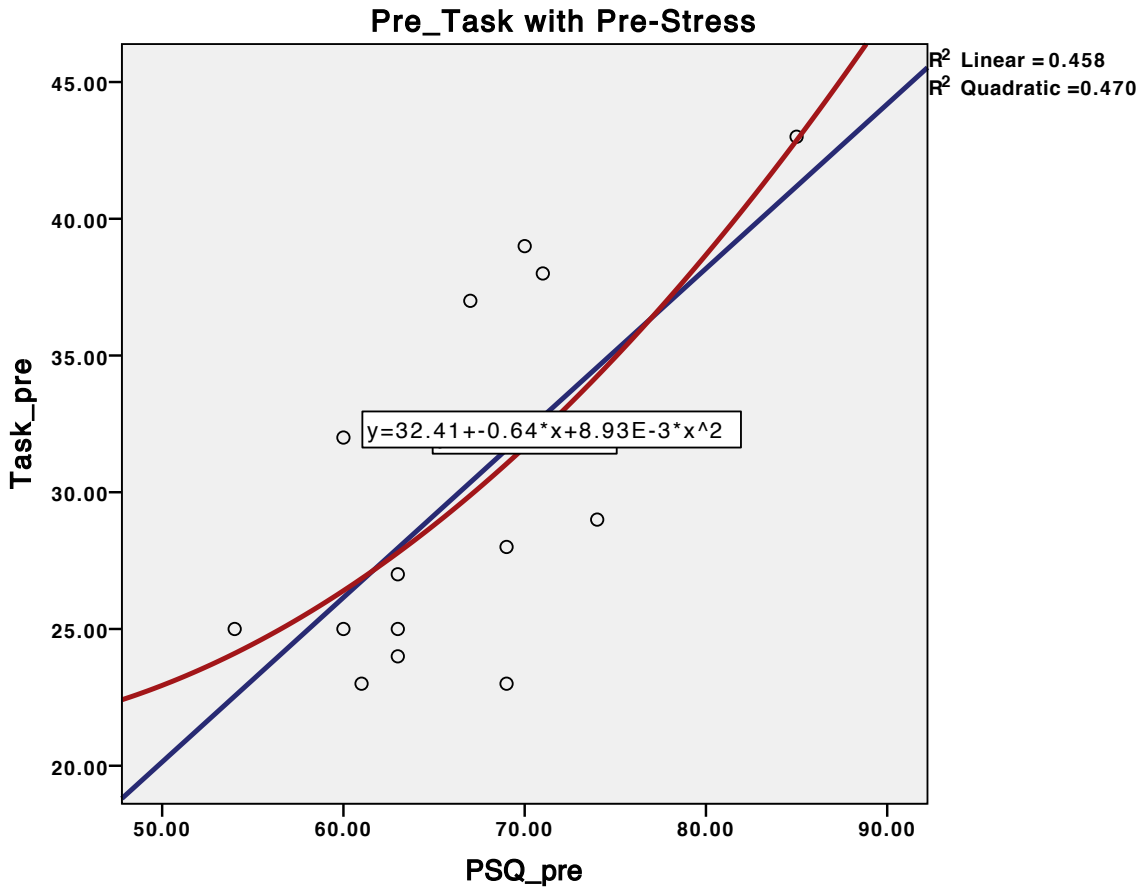


Figure 6. Pre-Simulation Stress and Pre-Simulation Task

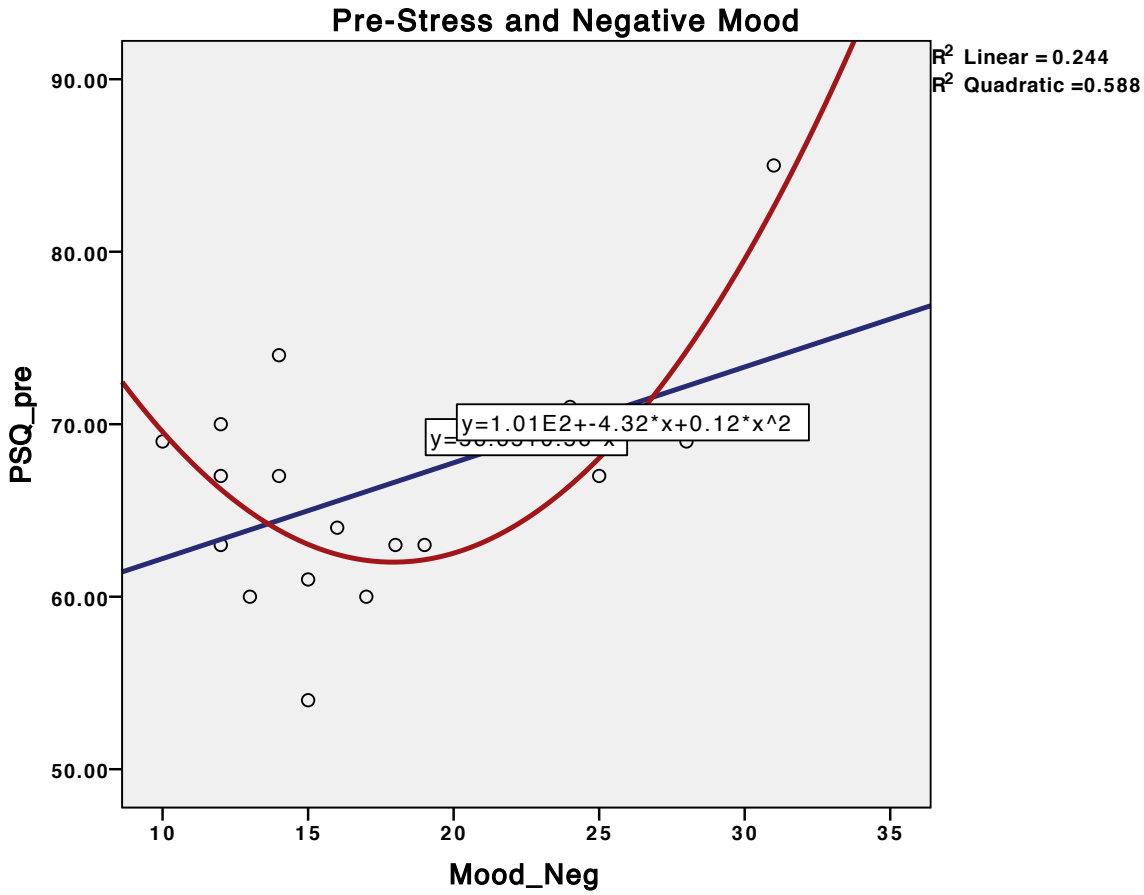


Figure 7. Pre-Simulation Stress and Negative Mood

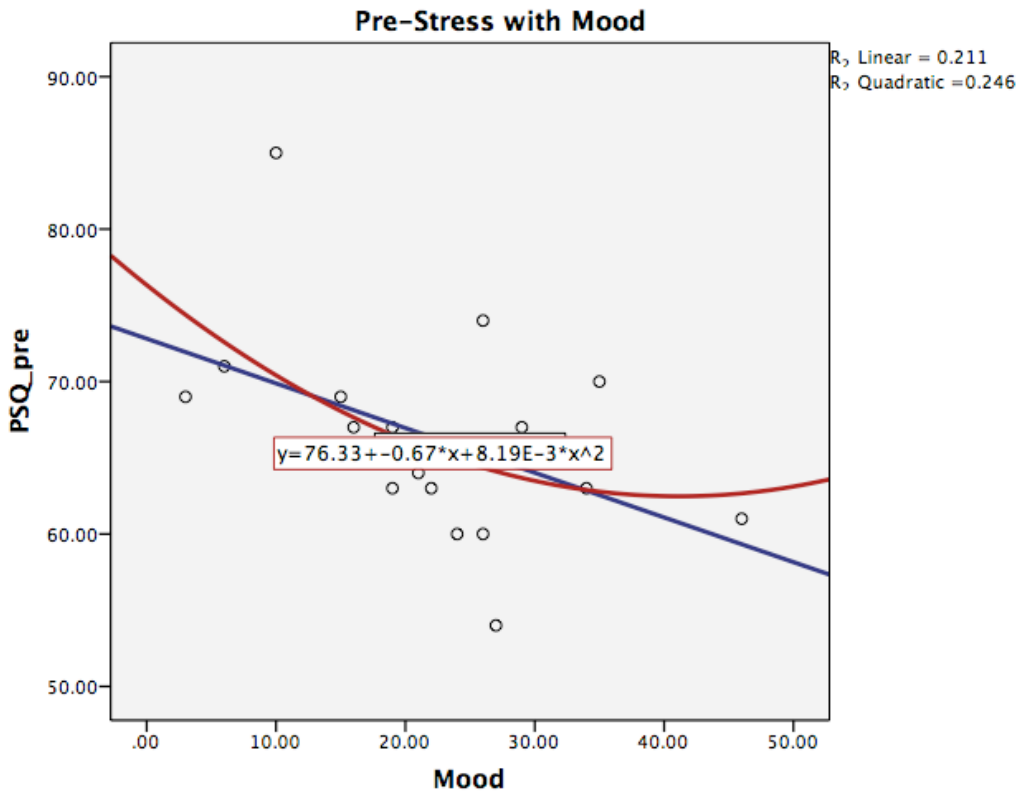


Figure 8. Pre-Simulation Stress and Mood

APPENDIX C

QUESTIONNAIRES

Perceived Stress Questionnaire
For each sentence, circle the number that describes how often it applied to you during the last few days.

	Almost Never	Sometimes	Often	Usually
1. You feel rested	1	2	3	4
2. You feel that too many demands are being made on you	1	2	3	4
3. You are irritable or grouchy	1	2	3	4
4. You have too many things to do	1	2	3	4
5. You feel lonely or isolated	1	2	3	4
6. You find yourself in situations of conflict	1	2	3	4
7. You feel you are doing things you really like	1	2	3	4
8. You feel tired	1	2	3	4
9. You feel you may not manage to attain your goals	1	2	3	4
10. You feel calm	1	2	3	4
11. You feel you have to many decisions to make	1	2	3	4
12. You feel frustrated	1	2	3	4
13. You are full of energy	1	2	3	4
14. You feel tense	1	2	3	4
15. Your problems seem to be piling up	1	2	3	4
16. You feel you are in a hurry	1	2	3	4
17. You feel safe and protected	1	2	3	4
18. You have many worries	1	2	3	4
19. You are under pressure from other people	1	2	3	4
20. You feel discouraged	1	2	3	4
21. You enjoy yourself	1	2	3	4
22. You are afraid for the future	1	2	3	4
23. You feel you are doing things because you have to not because you want to	1	2	3	4
24. You feel criticized or judged	1	2	3	4
25. You are lighthearted	1	2	3	4
26. You feel mentally exhausted	1	2	3	4
27. You have trouble relaxing	1	2	3	4
28. You feel loaded down with responsibility	1	2	3	4
29. You have enough time for yourself	1	2	3	4
30. You feel under pressure from deadlines	1	2	3	4

Positive and Negative Affect Scales

Pre-study :

This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past few days

1	2	3	4	5
very slightly or not at all	a little	moderately	quite a bit	extremely

_____interested	_____irritable
_____distressed	_____alert
_____excited	_____ashamed
_____upset	_____inspired
_____strong	_____nervous
_____guilty	_____determined
_____scared	_____attentive
_____hostile	_____jittery
_____enthusiastic	_____active
_____proud	_____afraid

APPENDIX D

INFORMED CONSENT

INTRODUCTON

Cognitive Performance Study

The purposes of this form are to provide you (as a prospective research study participant) information that may affect your decision as to whether or not to participate in this research and to record the consent of those who agree to be involved in the study.

RESEARCHERS

Dr. Nancy J. Cooke of ASU's College of Technology and Innovation has invited your participation in a research study conducted by an ASU Masters in Applied Psychology student, Maria Elena Gomez-Herbert.

STUDY PURPOSE

The purpose of this research is to examine how cognitive capacities are affected during a fire simulation. Your results will be completely anonymous and will NOT be used to compare your performance to others in the department, or for retention or promotion purposes.

DESCRIPTION OF RESEARCH STUDY

If you decide to participate, then as a study participant you will join a study to examine how cognitive capacities are affected during a fire simulation. All cognitive tasks will be conducted over the Internet using a website specifically designed by Dr. Vaughn Becker of ASU for the Mesa Fire Department. Cognitive tasks will take 5 minutes to complete. You will also be asked to fill out paper questionnaires, which will take approximately 5-10 minutes. For both methods of data collection, no personally identifying information will be collected. You will be assigned an identifier consisting of letters and numbers and your name will not in any way be associated with the identifiers.

If you agree to participate, then your participation will involve logging on to the website and completing the tasks three times during your training and completing a total of three questionnaires.

RISKS

We do not anticipate that you will experience any discomfort or negative effects, but as with any research, there is some possibility that you may be subject to risks that have not yet been identified. If at any time you would like to discontinue your participation, you may do so without penalty.

BENEFITS

Although there may be no direct benefits to you, your participation in the research will help the Virtual Incident Command Center (VICC) to better understand the realism level of their high fidelity simulations and the impact of a high stress, realistic simulation on cognitive functioning.

NEW INFORMATION

If the researchers find new information during the study that would reasonably change your decision about participating, then they will provide this information to you.

CONFIDENTIALITY

All information obtained in this study is strictly confidential unless disclosure is required by law. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you. In order to maintain confidentiality of your records, you will be identified by a randomly selected subject number, and no personally identifying information will be maintained for any participants at any time.

WITHDRAWAL PRIVILEGE

It is ok for you to say no. Even if you say yes now, you are free to say no later, and withdraw from the study at any time. Your decision will not affect your relationship with the Mesa Fire Department, Arizona State University or otherwise cause a loss of benefits to which you might otherwise be entitled.

COSTS AND PAYMENTS

The researchers want your decision about participating in the study to be absolutely voluntary. There is no payment for your participation in the study.

COMPENSATION FOR ILLNESS AND INJURY

If you agree to participate in the study, then your consent does not waive any of your legal rights. However, no funds have been set aside to compensate you in the event of injury.

INVESTIGATOR'S STATEMENT

"I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided (offered) the subject/participant a copy of this signed consent document."

Signature of Investigator_____ Date_____

VOLUNTARY CONSENT

Dr. Cooke will answer any questions you have concerning the research study or your participation in the study, before or after your consent. You may contact her at 480-988-2173, or nancy.cooke@asu.edu if you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk; you can contact the Chair of the Human Subjects Institutional Review Board, through the ASU Research Compliance Office, at 480-965 6788.

This form explains the nature, demands, benefits and any risk of the project. By logging on to the website, you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In continuing to participate in the study, you are not waiving any legal claims, rights, or remedies.

Participant signature_____Date_____

APPENDIX E

IRB APPROVAL

ASU Knowledge Enterprise Development

APPROVAL: EXPEDITED REVIEW

Nancy Cooke
TEIM: Technological Entrepreneurship and Innovation Management
480/988-2173
Nancy.Cooke@asu.edu

Dear Nancy Cooke:

On 12/19/2013 the ASU IRB reviewed the following protocol:

Type of Review:	Initial Study
Title:	Effects of stressors and emotion on individual and team cognitive performance
Investigator:	Nancy Cooke
IRB ID:	STUDY00000418
Category of review:	(3) Noninvasive biological specimens, (7)(b) Social science methods, (7)(a) Behavioral research
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• CONSENT.pdf, Category: Consent Form; • GomezHerbert_IRB2.docx, Category: IRB Protocol; • PSQ.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • PANAS.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • MCC MOU Added Line 12-19-12 .doc.pdf, Category: Other (to reflect anything not captured above); • RECRUIT.pdf, Category: Recruitment Materials;

The IRB approved the protocol from 12/19/2013 to 12/18/2014 inclusive. Three weeks before 12/18/2014 you are to submit a completed "FORM: Continuing Review (HRP-212)" and required attachments to request continuing approval or closure.

If continuing review approval is not granted before the expiration date of 12/18/2014 approval of this protocol expires on that date. When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:
Nancy Cooke

APPROVAL: MODIFICATION

Nancy Cooke
Human and Environmental Systems
480/988-2173
Nancy.Cooke@asu.edu

Dear Nancy Cooke:

On 3/7/2014 the ASU IRB reviewed the following protocol:

Type of Review:	Modification
Title:	Effects of stressors and emotion on individual and team cognitive performance
Investigator:	Nancy Cooke
IRB ID:	STUDY00000418
Funding:	None
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• Informed Consent.pdf, Category: Consent Form; • GomezHerbert_IRB_022714 MOD.docx, Category: IRB Protocol; • PANAS.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • PSQ.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • MCC MOU Added Line 12-19-12 .doc.pdf, Category: Other (to reflect anything not captured above); • Recruitment Materials.pdf, Category: Recruitment Materials;

The IRB approved the modification.

When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:

APPENDIX F

RECRUITMENT MATERIALS

Fire Service Professional,

The Virtual Incident Command Center (VICC) of Mesa Community College and the Arizona State University Department of Applied Psychology are collaborating on a research study to measure stress and its effects on performance in critical response personnel. We want to invite you to participate in the study during the upcoming Sets and Reps training session at the VICC. Volunteers will be asked to complete three kinds of surveys before and after their individual evaluation. Questionnaires will take approximately 5-10 minutes to complete. Volunteers will also be asked to complete three sets of simple cognitive tasks upon arrival for familiarization and then before and after the firefighting exercise. If you are interested in participating in this important research, please fill out the informed consent attached and bring it with you to the class. I also ask that you please familiarize yourself with the cognitive tasks you will complete during the study by following the link https://asuclas.qualtrics.com/SE/?SID=SV_23oVaE8yWisLJVb. Please feel free to contact me directly at malena6811@gmail.com with questions you have.

Thank you for your consideration.

Maria Elena Gomez-Herbert