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A Breathing Intervention to Enhance Cardiac Regulation and Mitigate Stress in Police Cadets

Samantha Napier
University of Central Florida

A BREATHING INTERVENTION TO ENHANCE CARDIAC REGULATION AND MITIGATE STRESS IN POLICE CADETS

by

SAM NAPIER
B.S. University of Cincinnati, 2000
M.S. Embry Riddle Aeronautical University, 2009

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Major Professor: Gerald Matthews

ABSTRACT

Maintaining effective performance under stress can be challenging, especially in the dangerous environments encountered by the police and military personnel. This document reviews the impact of stress on performance, discusses breath interventions as a means of stress mitigation, suggests an approach for exploring the value of a breath intervention in police cadets, tests, analyzes, and discusses a test of this method and results. Biofeedback training can be used to produce resonance breathing that is synchronized with heart rate and optimizes heart rate variability (HRV). This intervention was expected to alleviate physiological and subjective stress responses. Studies reviewed confirm that higher HRV is associated with lower stress and better cognitive performance. Training resonance breathing produces similar results when studies are well-designed. Relative to controls, resonance breathing training should improve the performance of police cadets on a series of cognitive and physical tests included in their curriculum, and on a simulated operational scenario given at the end of training. Research also tested whether personality traits associated with resilience predict higher baseline HRV and better performance during training.

To Twig, Chloe, and Maticus may the force be with you, always.

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CHAPTER ONE: INTRODUCTION

Background

Many work environments require the completion of cognitive and motor aspects of tasks under high stress (Matthews, Davies, Westerman, & Stammers, 2000). Stress can have a negative influence on peak performance in many contexts. Less than peak performance might mean the difference between winning and losing for athletes (Gould & Udry, 1994). Regulating stress is not just a problem for athletes. It is also a problem facing members of the military, police, and firefighters (Driskell & Johnston, 1998), who must also function under high stress conditions. Lack of peak performance for them may mean the difference between life and death.

The job of police officer is often stressful (Collins & Gibbs, 2003; Hope, 2016; Patterson, Chung, & Swan, 2014). The conditions they work under are stressful due to problematic organizational characteristics, the pressures put on them by the media public, and working in a flawed criminal justice system (Collins & Gibbs, 2003; Patterson et al., 2014). In addition to the threat of personal harm, police officers' jobs may require systematic problem solving and the need to move quickly to a state of heightened arousal that is ideal for performance (U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2004). Once an officer responds to a situation he or she must decide if the situation is critical enough to intercede. Interceding may result in the officer successfully de-escalating the situation or needing to engage in the use of force to resolve a violent situation (Hope, 2016). Whatever decision has been made the officer must also have the ability to explain decisions made after the fact (U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2011;

Hope, 2016). These life and death decisions may need to be made quickly with ambiguous information under evolving circumstances (U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2011; U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2004).

Stress can impact performance in several different ways, further explored below. Broadly, stress has the potential to negatively impact attention and working memory (which increases the likelihood of cognitive overload), as well as motor skills (Matthews, et al., 2000). Physiological and psychological stress responses may impact how an individual performs, feels, and thinks (Sutarto, Wahab, & Zin, 2010).

Additionally, performance in competition can be notably different than performance in practice due to the differences in stress levels experienced between the two settings (Wilson, Peper, & Schmid, 2006). According to Gould and Udry (1994), an athlete's skill in regulating his or her levels of emotional stress is often seen as determining positive or negative influences on competitive performance. Self-regulation of stress and the arousal response that stress induces are critical to obtaining peak performance in athletes. Gould and Udry (1994) suggested that, to achieve peak performance, coaches and sports psychologist need to understand how stress influences performance and how athletes can be taught to regulate their own states of stress to achieve peak performance. This may apply to other domains.

Training individuals how to self-regulate stress has not been straightforward and has multiple challenges. Attempts to teach regulation of stress for military personnel have not only been made in training prior to deployment but also in treatment of depression, Post-Traumatic Stress Disorder (PTSD), and traumatic brain injury effects upon return (Rice, Boykin, Jeter, Villarreal, Overby, & Alfred, 2013). One challenge is the development of effective stress regulation training. Evaluating the effectiveness of regulation training has been problematic for the Army because training systems are typically unable to produce high enough stress levels to allow for accurate determinations of the relationships between stress and performance (Patton, 2014). An example of this issue might be that the stress associated with being shot at is not accurately represented with a visual display such as a life bar (such as occurs in video games). Another challenge in training is determining the maximum rate at which dispensation of stressful stimuli can be increased without compromising positive training. Often in previous work, the sheer volume of stressful stimuli increased so rapidly that soldiers became too stressed to perform (Johnston, Napier, & Ross, 2015). The resulting lack of training effectiveness meant that 10-50 percent of casualties in an operational environment may be psychological in nature (Thompson & McCreary, 2016). A meta-analysis on the training of self -regulation of stress for police officers concluded that the effect sizes were too small to indicate that any of the training was effective (Patterson, Chung, & Swan, 2014). There is a clear need for more research in this area. Due to these high stress situations police officers are in danger of both deficits to their performance and stress related health problems (Hope, 2016; Patterson, et al., 2014).

In general, over time chronic stress can cause health issues with the cardiovascular system, muscles, skeleton, immune system. It can lead to psychological disorders, suicide, injuries, and cancer (Patterson, et al., 2014).

Specifically, police stress has been correlated with psychological problems such as anxiety, depression, flashbacks, and panic attack (Patterson, et al., 2014). It may also lead to physiological problems such as headaches, stomach aches, back aches, ulcers & heart attacks. The chances of a heart attack are so high for police officers in large cities that they may be allowed to claim workers compensation even if not on duty (Patterson, et al., 2014).

Police officers' performance may suffer due to stress. Stress levels have been correlated with lower job appraisals by supervisors as well as well as increased number of complaints about police behavior by residents (Patterson, et al., 2014). Police officers are vulnerable to response and memory performance issues, that Hope (2016) suggested may be higher than normal due to stress induced by the extra cognitive load created by intervening in a critical situation. Stress is believed to be a key component associated with the decrease in shooting hit rates from 90% on a range to 15-50% in real life (Hope, 2016). It was also correlated with working a swing shift and was associated with increased subjective reports of general mistakes and especially infractions related to safety (Hope, 2016). This is safety issue includes forgetting details of critical incidents, making critical mistakes with firearms (Hope, 2016) and either failing to perceive or misreading cues that mark an impending assault (U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2011).

CHAPTER TWO: LITERATURE REVIEW

Stress and Performance

This review of the literature will address key issues for developing and validating an effective stress mitigation technique that could be used later to feed models of human behavior, and support stress mitigation for high-threat environments such as those faced by the military and the police. It will review the nature of stress and its psychology. The review will focus especially on stress as a dynamic process and individual capacities to regulate that process. It will also cover the impacts of stress on performance from a process-based perspective. The final review section covers methods for stress mitigation under complex situations such as those confronted by military and law enforcement. It identifies self-regulation based on breath control techniques as especially effective in present context. The review of literature supports recommendations for future research.

To better understand the problem three questions were asked. What defines stress; what impacts on performance does stress have; and what can be done to mitigate the impacts of stress on performance?

What Defines Stress?

Stress is a complex phenomenon that has been defined in different ways by psychologists. This section contrasts stimulus-based and response-based definitions that have been distinguished in order to better understand stress, followed by a transactional definition that may better capture the dynamic nature of stress.

Stress as Stimulus

According to the stimulus-based definition, the stimulus is any objective change in the outside world that creates stress for the individual (Matthews, 2000). Some “stressor” stimuli, such as loud noise or personal injury, are intrinsically harmful. The limitation of this definition is that a stressful event for one person may not have be stressful for another, in part because people are able to actively regulate stressor impacts. Capacity to cope through self-regulation, with the psychological and/or physical circumstances confronted on a mission (military or police) may have impact fitness to perform duties successfully (Krueger, 2008), so that evaluating stressful stimuli on an objective basis may not indicate whether or not performance will be impaired. However, the definition has the advantage in real-life contexts of directing the researcher’s attention towards actual events that may provoke stress.

General operational stressors for the military and police include: “workload, information reliability/ambiguity, time pressure, command pressure, task interdependence around team members, improper equipment, equipment failure, and multi-tasking” (Napier & Johnston, 2014). Studies using police report similar stressful events as military including (Patterson, et. al., 2014),

- Another member of the police being killed on the job,
- Killing another person while on the job,
- Seeing minors who were dead or had been physically hurt
- Undergoing a physical assault

Stress as Response

The reaction a person has to a potentially threatening stimulus is called the stress response. The response is viewed in terms of physiological markers, such as changes in the autonomic nervous system (ANS) or subjective psychological responses, such as anxiety or depression. Wilson, et al. (2006) suggested that most external stimuli or signals generate responses in the individual. These include new thoughts, alterations in the emotional state and related changes in the physiological response of the body. Combat stress is a type of stress response that includes physical and psychological markers that emerge from multiple battle related stimuli. Those unable to cope with combat stress typically have inferior performance and possibly clinical symptoms (Krueger, 2008). The advantage of the response-based definition is that it accommodates varying individual differences in reactions to stimuli. However, a focus on the response alone neglects the role of the events that precipitated the response. Furthermore, the various physiological and subjective stress responses often fail to intercorrelate highly, suggesting that the notion of a single, general response is inadequate to capture the complexity of reactions to demanding circumstances (Matthews et al., 2000). The stress response can be assessed through subjective scales such as the Dundee Stress State Questionnaire (DSSQ) (Matthews, 2016b) as well as physiological measures.

Transactional Theory of Stress

The transactional theory of stress (Lazarus & Folkman, 1984; Lazarus, 1999) defines stress as an interaction between external events and internal responses and thus integrates elements of stimulus- and response-based definitions. According to the transactional theory (Matthews, et al., 2000) the stress response is a property of the interplay between external stimuli and an individual's negative assessment of her or his ability to cope and respond to those stimuli. Both conscious and unconscious appraisal requires processing capability. A stimulus only induces stress if the person expects that dealing with it would overload his or her capabilities or resources (Fatkin & Patton, 2008). During the primary appraisal of a situation, a person notices a potentially stressful event and decides if it is risky or not and assesses the seriousness of the risk (Cohen, Brinkman, & Neerincx, 2015; Thompson & McCreary, 2016). A challenge assessment is neutral or positive. A threat assessment is negative. During a secondary appraisal the person decides if he or she has the ability to cope with the risk (challenge) or lacks the capability or resources to cope with the risk (threat). Finally, the person chooses some approach to deal with the issue. For example, if the interpretation of the physiological responses to adrenalin is positive, the emotions are not associated with stress. If the interpretation of the situation is negative, the emotions reflect a negative response. Ben-Zeev, Fein, and Inzlicht (2005) suggest that when physiological arousal due to stress is perceived as having been created from a non-threatening source, the individual turns attention and resources to the task at hand. When physiological arousal is perceived as being due to a threat, people who tend toward maladaptive coping strategies often choose to use resources (such as processing capability) to suppress thoughts, lower expectations or some other response that injures performance. This requires resources for both the maladaptive strategy and performance. The transactional theory also accommodates an individual's ability to self-regulate her or his own level of stress. For example, athletes regulate their emotions such as anxiety and control their attention and concentration in the face of distraction (Gould, Dieffenbach, & Moffett, 2002; Williams & Krane, 2001; Wilson, et al., 2006). Thus, one of the strategies for mitigating stress suggested by the theory is to enhance an individual's capacity to regulate stress and negative emotion adaptively as a way to avoid major negative impacts on performance. It is suggested that strategies to self-regulate be taught alongside functional coping strategies. This requires an explanation of the physiological and cognitive systems that control stress.

Neurological Bases for Stress Response

The physiological and cognitive systems influence each other to control stress. Two brain systems typically respond to potentially stressful stimuli and control the interaction between the brain and the body. The first is the autonomic nervous system (ANS). The second is the hypothalamic-pituitary-adrenocortical (HPA) axis.

Autonomic Nervous System (ANS)

The ANS monitors the body and maintained homeostasis. ANS support is also crucial if the body requires a limited shift from homeostasis to withstand environmental demands. The ANS is divided into the sympathetic system and the parasympathetic system. Typically (but not always), the sympathetic system is responsible for quick responses that mobilizes the organism rapidly. This includes the flight or fight response (Ulirich-Lai & Herman, 2009). The stressor causes the amygdala to send a message to the hypothalamus which in turn sends a message to the adrenal medulla to release adrenalin. This happens within seconds of the initial stressor. Sympathetic activation is responsible for responses commonly used to index stress, including cardiac acceleration, phasic increases in skin conductance, and constriction of the pupil of the eye. The complimentary parasympathetic system is usually slower to activate and responds to stressors that do not require a rapid response. It also works to counter the sympathetic response.

Arousal of any given system can be controlled by the sympathetic nervous system, the parasympathetic nervous system, or a combination.

Hypothalamic-Pituitary-Adrenal (HPA) Axis

In addition to the immediate ANS response, the body uses the HPA axis to control physiological stress reactions (Ulirich-Lai & Herman, 2009) over longer time periods. After the stress stimulus is received the amygdala sends a signal to the hypothalamus to initiate the HPA cycle. The hypothalamus releases corticotrophin releasing hormone (CRH) to the pituitary gland which in turn secretes adrenocorticotropic hormone (ACTH) to the adrenal cortex. ACTH stimulates the adrenal cortex to release cortisol into the blood stream. This helps the body gain access to stored energy and controlled blood pressure. The HPA response is slower acting than that of the ANS. Maximum blood concentration of cortisol occurs 10 minutes after the initial stressor; however, it has the possibility of remaining elevated for hours. Concentration of cortisol in the blood stream also acts to turn the HPA stress response off. When critical levels are reached the cortisol acts as negative feedback to the hypothalamus and to the pituitary gland to shut down production of CRH and ACTH.

What Impacts on Performance does Stress Have?

Capacity Model of Stress Impairments to Performance

Researchers use a variety of different stress manipulations and performance tasks to investigate stressor effects. This literature is too complex and extensive to review in its entirety here. Findings conform to the cognitive patterning principle (Hockey & Hamilton, 1983), i.e., that any given stressor may impair, enhance, or have no effect on performance (Matthews, Wohleber, &

Lin, 2019). This is dependent on the information-processing demands of the task. However, one result that generalizes across multiple stressors and tasks is that stress factors produce general deficits in attention and working memory. Such deficits potentially impact performance on a wide range of cognitively demanding tasks (Matthews, et al., 2019). Figure 1 illustrates some of the key processes that mediate between external stress factors and impairment in performance according to the conceptual model developed by Matthews, et al. (2019). The elements of the capacity model of stress impairments will be discussed in more detail.

Environmental Stressors

Environmental stressors are defined as external events or conditions that are not directly related to the goal or task (Matthews, et al., 2000). These represent stress as a stimulus. Whether they contribute directly to loss of processing capacity by influencing neural functioning in the brain structures that support attention, or indirectly (such as distraction) the result can be cognitive overload.

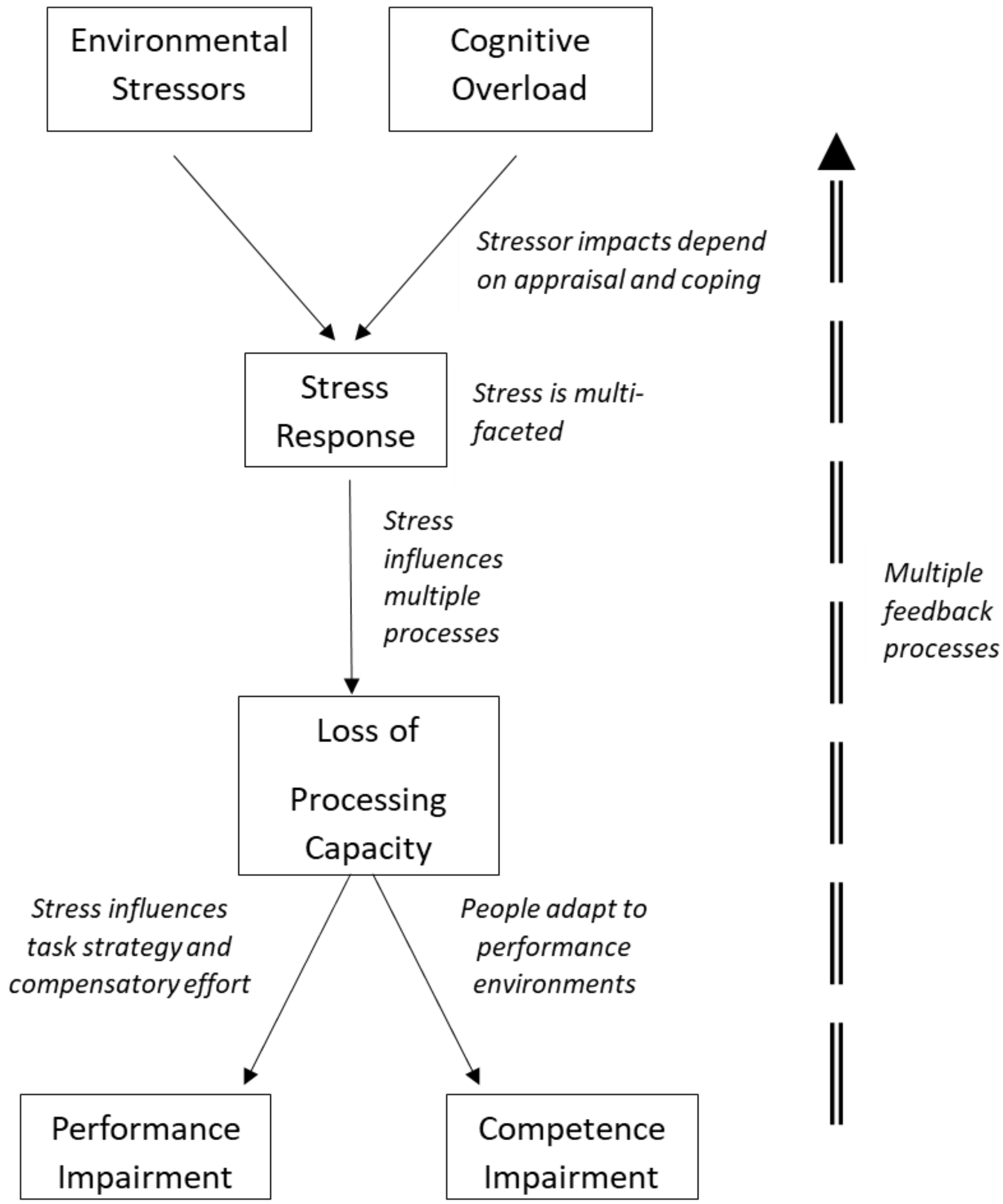

Figure 1: Capacity model of stress impairments

Cognitive Overload

Cognitive overload is a concept that came from resource theory (Reinecke & Trepte, 2008) . Under resource theory, a person has finite resources at his or her disposal to deal with task demands. If the total demands of the task exceeded resources available, the individual may become overloaded and resource-limited information-processing may degrade (Matthews, et al., 2000). Overload results from changes both in the demand for resources to support information-processing and the supply available.

Stress Response

In challenging environments, external environmental stressors and overload from task demands interact to provoke a variety of physiological and psychological stress responses, some of which were discussed earlier. However, from the performance perspective, the important issue is to identify the components of the stress response that impact attention and information-processing (Hancock & Matthews , 2015). Using a neurological perspective, stress may impair functioning of the prefrontal cortex areas that support attention, working memory and executive control of processing (Arnsten, 2009). The stress response also includes psychological components that may impair task-directed attention. Maladaptive elements of the stress response include worry that diverts resources from task processing (Sarason, Sarason, & Pierce, 1995). For example, performance deficits in test anxiety are attributed to worry (Zeidner, 1998).

Loss of Processing Capacity

Processing capacity is broadly defined as the person's overall ability to process information, (Matthews, Warm, Shaw, & Finomore, 2014) and resources are viewed as "energy" that is

deployed and re-deployed as needed to deal with the situation at hand. A person has limited number of resources (capacity) at his or her disposal (Reinecke & Trepte, 2008). Using a resource for a cognitively demanding task means it is not available for some other task.
Loss of processing capacity may impact skilled performance in various domains, especially when skill execution requires high levels of working memory and attention. Environmental stressors, cognitive overload and the stress response may impact processing capability directly via neural pathways or indirectly as it allocates resources to cope with the stressor or the person's reactions to it. The loss of processing capability leads to problems with narrowing of attention, inconsistent, or wandering attention (Cohen, et al., 2015; Reinecke & Trepte, 2008), deficits in short-term memory (Reinecke & Trepte, 2008), memory formation, recall (Cohen, et al., 2015), learning, adapting to new situations (Thompson & McCreary, 2016) and issues with decision making (Patton, 2014). These failures occur as the person focuses increasing levels of attention on controlling his or her stress levels. Loss of capacity is also detrimental to skilled performance, especially in novices. The early stages of skill acquisition are highly dependent on working memory and verbal representations of the activity performed (Anderson, 1987).

Performance Impairment

Loss of capacity creates a vulnerability to actual performance impairment, but the vulnerability may not be apparent if the task is easy, requires few resources, or requires primarily automatic processing. In addition, people may be able to compensate strategically for resource limitations, especially if they had expertise in the task domain concerned. Thus, stress does not necessarily lead to observable, acute performance impairment in real-life settings, and more detailed investigation of specific domains and contexts is necessary to determine the actual stress impact.

There are various types of research that demonstrate performance impairments in applied settings. Below are some examples.

Test Anxiety

Test anxiety is a stress response to evaluations that generally results in performance impairments (Matthews, et al., 2019). Test anxiety is marked by worry about poor performance, the adverse outcome that results from that performance, as well as repeated negative self-appraisals. The person is typically conscious that the worry and self-appraisals were the cause of the performance issue which leads to further negative self-evaluations and intensifies the effect. Attentional resources are used to maintain self-esteem rather than to complete the task at hand. The worry and endless cycle of self-assessment impedes attention, working memory and memory retrieval (Matthews, et al., 2000). This cycle impacts people who are otherwise high academic achievers and are well-prepared. Exam scores fall short of the person's actual competence and ability. Test anxiety could impact police cadets as they take classes to become an officer.

Decision Making

Decision making can impose a high demand for resources such as attention and working memory and thus is easily impacted by stress. In the police and military context there is a particular concern that stress may impair decisions made under high time pressure. Working on teams may help or hinder the ability to handle stress and make decisions. Expert teams are often better at dealing with stress because their superior communication skills, shared mental models, shared purpose, expert leaders, as well as their emotional connections and trust allow them to absorb higher workload requirements of communicating and decision making in a team (Salas, Diazgranados, & Lazzara, 2009). The opposite may be true for novice teams where lack of expert team characteristics may increase stress by burdening teams with additional mental processes necessary to coordinate and communicate decision making to the group (Cohen, et al., 2015). These additional processes may also leave an individual low in task knowledge frozen with indecision in a high stress situation (Wilson, et al., 2006).

Typically, decision making is thought of in four steps labeled Observation, Orient, Decide, and Act (OODA) (Richards & Addams, 2011). The first step, Observation, requires attentional resources as the person focuses on the problem. The second step, Orient, involves synthesizing observations with previous experience and then analyzing them. The third step is to Decide what action to take, and the fourth step is to Act on the decision. Breakdowns in the process often happen in the orient step (Cohen, et al., 2015). Failures include premature closure, non-systematic scanning, and temporal narrowing (Cohen, et al., 2015). Premature closure happens when there is a failure to look at all the available options. In non-systematic scanning, the person does not analyze the choices in a methodical way. Finally, temporal narrowing involves not taking the time needed to appraise the choices.

Competence Impairment

Competence impairment impacts the individual's ability to learn and reach their full potential. Specifically, Matthews et al. (2019) found that when working memory or attention became overloaded due to stress, ability to learn new skills may be instantaneously degraded. This was more important in long term learning. Since this study is not looking at long term learning, it won't be further discussed here.

Critique of the Capacity Model of Stress Impairments

The main boxes in Figure 1 represent the capacity model of stress. However, the model has some criticisms in that it is over simplified. Italic text on the Figure highlight some of the complexities and criticisms of the stress process that may not be captured by the model.

Stressor Impacts Depended on Appraisal and Coping

The transactional theory emphasizes that external stressors and cognitive load do not have fixed impacts on response irrespective of context (Matthews, 2000). A given objective event could produce different stress responses depending on how the individual appraised the personal significance of the event, and on the coping, strategy chosen to manage the event.

Appraisal and coping depend on both the nature of the situation and on stable individual differences impersonality traits and preferred coping styles. These provide a link between environmental stressors and cognitive overload and stress response. Individuals differ in the extent to which they appraise stressors as threatening, in their evaluation of their own coping capabilities, and in the strategies, they implement to manage stressful events. Personality traits and coping styles of the individual may make it more difficult to determine how stress impacted performance (Patton, 2014) and are important variables when studying stress (Thompson & McCreary, 2016), as further discussed in the next section. People consistently favor their own preferred coping style which combines with their personality, life experiences, and knowledge

(Matthews, 2000). The interpretation of an event is exclusive to the individual and regulates what emotions are experienced and if/what actions are taken (Matthews, et al., 2000). Some common coping styles include emotion-focused coping, problem focused coping, and social support.

Anxiety research provides examples of how different coping responses result in varying outcomes. An individual who chooses an active, problem focused approach may be able to compensate with more effort to maintain performance (Matthews, et al., 2019). A person who uses a more emotional focused strategy, such that the person is focused on critical self-thoughts, may impair her or his processing efficiency needed for the task (Matthews, et al., 2000).

Stress is Multifaceted

Stress is multifaceted in nature (Matthews, 2016a). The individual's personality traits, emotional states, physiology, coping abilities, and the characteristics of the task itself all combine to elicit different coping responses. The ever-changing interaction between all these components makes it difficult to define exact linkages between stress and performance (Matthews, et al., 2019). Different elements of stress may be associated with performance breakdown, depending on the context in which stress develops.

Stress Influenced Multiple Processes (Information-Processing Components)

Stress influences multiple information-processing components (Hockey & Hamilton, 1983). Those include general alertness, attentional selectivity, speed, accuracy, and even short-term memory capacity.

Stress Influenced Task Strategy and Compensatory Effort

According to the capacity model of stress, once the requirements for required resources to deal with task and stress processing exceed the supply, the person experiences overload and performance begins to decline. However, the actual impact of reduced resource availability on performance depends on the way a person compensated for stress. In general, the person adjusts attention by varying the focus of attention and the level of effort or how many resources are engaged in coping efforts (Matthews, et al., 2000). Effective coping is adaptive and lessens negative performance effects. An individual whose stress is at a (non-overwhelming) ideal level may cope with stress via an active control method and by increasing effort. However, in some cases, people choose a maladaptive coping style (such as excessive worry), a strategy that exacerbates performance deficits (Zeidner, 1998). Similarly, a maladaptive coping response to fatigue stress is observed when the individual chooses not to apply greater effort to cope. This apathetic approach results in a decline in performance.

People Adapted to Performance Environments

Over extended time periods, people acquire not only task skills, but coping skills that manage the stressors typically present in the performance environment. The transition from novice to expert relies on adaptation to performance environments.

Multiple Feedback Processes

The transactional model of stress emphasizes the dynamic nature of the stress process (Lazarus, 1999). Events unfold over time so that both the external environment and the person's appraisal and coping methods are liable to change. Feedback processes take place at multiple stages of the model shown in Figure 1 over differing timespans (Matthews, et al., 2019).

Individual Differences in Resilience and Stress Vulnerability

Individual differences include abilities related to learning (aptitude) and performance of a given task (Matthews, et al., 2000). Different types of tasks require different abilities and aptitudes. As already indicated, there are pronounced individual differences in stress responses. People differ at multiple stages of the stress processes, e.g., appraisal of external stressors, coping style, sensitivity of different response systems, and total capacity available. Individual differences are assessed as both temporary states and stable traits. State measures such as psychophysiological response indices and the DSSQ are valuable for monitoring the individual's acute response to a stressor, and thus evaluate whether interventions effectively alleviated stress (Matthews, Campbell, Falconer, Joyner, Gilliland, Grier, & Warm, 2002). Trait measures are used to create predictions of stress response. Validated trait measures are used for personnel selection. This includes choice of personnel for high-stress specializations and tasks, and for personalized training to address an individual's vulnerabilities.

Like stress itself, individual differences in traits for resilience and vulnerability are complex, and there are multiple objective and subjective factors assessed. This approach takes on extra significance in situations where the stressors cannot be easily regulated. The section below summarizes the different types of measure that are used in assessment. Objective measures of resilience and vulnerability include psychophysiological assessment of response system sensitivity and performance-based measures such as working memory capacity. Relevant personality factors are measured by self-report questionnaires. Level of expertise may also moderate response to stressors.

Individual Differences in Resilience: Personality Factors

A range of individual difference factors may influence vulnerability to stress, including cognitive factors such as working memory capacity (Matthews et al., 2000) and expertise (Matthews et al., 2019). The present focus is on personality traits of the individual that tend to mitigate detrimental impacts of stressors. These traits taken as a whole are referred to as resilience (Matthews, 2016b). Hardiness and grit both show positive correlations with resilience. Hardy individuals tend to assess negative events in their lives as typical of life. This is accompanied by strong feelings of engagement and control in their life's work. They are also more open to change and challenges. Grit is more representative of longer-term goals and is the conviction and inclination to endure to accomplish goals despite hardships over time.

A trait that is generally associated with poorer resilience or stress vulnerability is neuroticism (Matthews, 2016b). Individuals high on the trait have a tendency toward negative emotional states. It is marked by emotional instability and associated with anxiety, depression and worry. Although there are several ways neurotic behavior and distress could interact, it is worth considering that this trait may result in maladaptive coping behaviors. A person who assesses a situation as threatening, uncertain, or uncontrollable may choose to self-criticize or avoid the problem entirely. This approach keeps an individual's distress high without mitigating the source of the problem.

Anxiety and neuroticism are both associated with deficits in attention working memory and executive control of processing (Matthews, et al., 2019). Anxiety involves exaggerated fears of harm due to potential threats (Matthews, 2000). These threats are often in the form of evaluations, as is the case in test anxiety and sports (Matthews, et al., 2019). In addition to problems concentrating, anxiety also decreases the person's ability to analyze ambiguous cues. Either anxiety or neuroticism are capable of increasing muscle tension. This means that perceiving and analyzing a situation as well as the choice of actions and both the choice and ability to engage in the physical movement needed to carry out these actions are all impacted by anxiety.

What Can be Done to Mitigate the Impacts of Stress on Performance?

As previously discussed, stress often has negative impact on performance. Optimizing performance may depend on finding a way to mitigate stress. On a very high level, there are multiple approaches for stress mitigation that are broadly categorized as follows (Matthews, 2000).

1. Change the objective environment or events that provoke the stress. Occupational stress might be mitigated by improving office lighting, redesigning work to provide manageable performance goals, or providing more support for workers with difficult assignments.

2. Relief of stress symptoms without addressing objective or psychological causes of stress. This approach includes the use of drugs including beta-blockers, anxiolytics and antidepressants. It includes relaxation techniques directed towards reducing negative

emotion or physical discomfort. For example, an organization might set aside time for employees to attend relaxation classes (Richardson & Rothstein, 2008).

3. Support for the individual's efforts to manage the stress process. Consistent with the transactional model of stress (Lazarus, 1999), people may be trained to evaluate events as manageable challenges instead of threats and choose effective coping strategies. Interventions of this kind include techniques such as mindfulness training and meditation that do not directly target appraisal and coping but instill adaptive patterns of thought and emotion that promote effective coping. A feature of this approach is that the person initiates and control stress management activities so that it represents a form of self-regulation.

These various approaches have all been proven to be effective (Richardson & Rothstein, 2008), but certain strategies may not be available or appropriate in all situations. For example, police and military personnel may find job redesign to prevent stress to be impossible as stressful events are inherent in the job. There may also be some ambiguity over the mechanisms through which some techniques alleviate stress. For example, mindfulness meditation may produce immediate relaxation, but also more long-term benefits associated with learning to observe situations and thoughts in a nonjudgmental manner (Sharma & Rush, 2014). Stress management may also incorporate multiple techniques operating in different modalities. In the present context, the primary focus is on self-regulation of stress because effective self-regulation may promote higher levels of cognitive and physical performance (Nicholls, Levy, Carson, Thompson, & Perry, 2016). The practical need is for techniques that emergency personnel could initiate to regulate stress at times of their own choosing, for example, prior to engagement with the stressful event or during breaks in the action. The remainder of this section considers self-regulation as an approach to stress management in more depth and reviewed some leading techniques.

Self-Regulation

Self-regulation is defined as the process by which a person controls, monitors and corrects thoughts, emotions, behavior, and concentration to reach an objective (Keith & Frese, 2005). There are various theories of self-regulation (Lord, Diefendorff, Schmidt, & Hall, 2010), but common to all is the idea that successful adaptation requires both monitoring and control functions. The monitoring function refers to awareness and insight into one's own mental function, whereas the control function covers strategies for influencing thoughts, emotions and motivations constructively. Control may be affected either through internally focused strategies such as "positive thinking", or through actively choosing beneficial activities such as sharing feelings with friends or physical exercise (Thayer, Newman, & McClain, 1994). Training self-regulation before challenging or threatening events supports management and control of the emotions associated with stress. Self-regulation allows the person to maintain or change the manifestation of an emotion in terms of how often, how intense, and how long it lasts and perhaps what form it takes (Cohen, et al., 2015). Learning emotion regulation is critical to be able to maintain performance when making decisions under high stress. Training individuals to recognize and regulate stress is thought to lead to better cognition and higher levels of well-being and relaxation (Sutarto, Wahab, & Zin, 2013).

It has been suggested that this self-regulative process was vital to achieve peak performance (Movahedi, Sheikh, Bagherzadeh, Hemayattalab, & Ashayeri, 2007) and was especially important in conditions where high stress negatively impacted performance (Wilson, et al., 2006). Sports performance is one such area. Traits characteristic of elite athletes (i.e. Olympic champions) have been investigated to determine factors they may all have in common (Gould, et al., 2002; Williams & Krane, 2001; Wilson, et al., 2006). Self-regulation of stress appeared in some form in all the results. The athletes were able to cope and control anxiety (emotional regulation), had the ability to cope with distraction (attention regulation) and had heightened concentration (attention regulation). Another area where high stress negatively impacted performance was in the military context. Combat missions were cited as an area where regulation of stress (or lack thereof) could have had dire consequences for performance (Thompson & McCreary, 2016). The maladaptive emotional arousal associated with anger and frustration led to reckless behavior and poor decision making. Regulation kept problems associated with the interaction between emotion and attention under control and allowed the individual to maximize performance.

Methods to Train Self-Regulation for Stress Mitigation

The importance of the relationship between stress and performance has led researchers involved in both sports and military situations to attempt to train self-regulation of stress to cope with high pressure (Adler, Bliese, Pickering, Hammermeister, Williams, Harada, & Ohlson., 2015; Johnston, et al., 2018; Napier, et al., 2016; Wilson, et al., 2006). Self-regulation of stress was part of the concept of mental readiness that was trained in military personnel (Thompson & McCreary, 2016). Self-regulation covered numerous strategies for intervening in the stress process. The different techniques and strategies have been broadly classified in terms of where in the process the intervention took place. Techniques could have (1) mitigated the initial development of stress by modifying antecedent processes, (2) shaped processing adaptively following initial exposure to a stressor, and (3) alleviated responses to stress. Some techniques influenced multiple stages of the stress process, but this classification is convenient for reviewing the different methods. Table 1 provides a summary of common methods to train self-regulation for stress mitigation. More detail is provided below for some techniques that were used to teach self-regulation to police.

Table 1: Methods to train self-regulation for stress mitigation

Category	Name of technique	Description
Mitigated the development of stress by modifying antecedent processes	Antecedent emotional regulation training (Webb, Miles, & Sheeran, 2012)	Teaches students to anticipate an emotional response before the associated stress escalates.
	Situation selection and modification (Webb, Miles, & Sheeran, 2012)	Person has ability to choose not to participate or alter the event that would evoke and emotional response
	Attentional deployment (Webb, Miles, & Sheeran, 2012)	Cannot choose or alter the situation. Deals with situation by regulating attention to control emotions.
	Reappraisal (Hariharan, et al., 2015)	Reduces high stress and impact of a negative emotion by focusing on something positive that came out of a negative event. Changes the emotion or its intensity.
Strategies for intervening in the stress process adaptively (or holistically)	Error management training (Keith & Frese, 2005)	Teaches emotional regulation and regulation of metacognition. Learn to perform difficult task through trial and error. Told to view mistakes as positive because mistakes enabled learning.
	Stress exposure training (Johnston, et al., 2015; Napier, et al., 2016)	Method to train stress regulation is to gradually expose students to increasing levels of stress. Three phases
	Mindfulness (Jha, Morrison, Dainer-Best, Parker, Rostrup, Stanely, 2015; Meland, et al., 2015; Rice & Liu, 2017)	Marked by conscious, deliberate, and directed attention usually starting with the breath. Helps teach self-regulation skills such as attention and emotion regulations, increasing body awareness, WM, and reappraisal.
Strategies for reducing subsequent stress response	Response focused training (Hariharan et al., 2015; Webb et al., 2012)	Occurs after the emotion is experienced.
	Suppression (Hariharan, et al., 2015; Gross, 1998)	Attempts to inhibit all responses to a negative emotion. Linked to more negative emotions, difficulty recovery from negative emotions, and decreased self confidence in the ability to deal with negative emotions.
	Relaxation techniques (Gould & Udry, 1994; Matthews, 2000)	Relax body to activate the parasympathetic nervous system to decrease stress at will under stressful conditions.
	Autogenic training (Gould & Udry, 1994)	Form of self-hypnosis. Results in feelings of warmth and heaviness that accompany relaxation.
	Progressive muscle relaxation with cue-controlled relaxation (Gould & Udry, 1994)	The person inhales while tensing muscles, then says a cue word while releasing tension and exhaling. Eventually the cue word triggers relaxation.
	Biofeedback training for stress regulation (Gould & Udry, 1994; Wilson, et al., 2006)	Sensors produce feedback that allow individuals to observe nuances in their physiological systems while stressed and make changes to their physiological processes.

Stress Exposure Training

Stress exposure training (SET) was a form of stress inoculation training that was altered to accommodate the stressors of combat and police work that cannot be depicted without the use of a simulator. This method gradually exposes students to increasing levels of stress (Johnston, et al., 2015; Napier, et al., 2016). Stress exposure took place under very specific conditions that regulated the amount of stress experienced. The first phase provided information on regulating the stress as it related to performance. These included emotional, social, cognitive, and physiological skills needed to cope. In the second phase, skills related to coping with stress, making decisions under stress, and adaptability were practiced with coaches. The third phase focused on practicing these skills within a training scenario where naturalistic tasks were used as triggers to practice the skills. Stress was increased incrementally so the individual was not overwhelmed while trying to master each skill. Raising stress in this way may have met the requirements needed in the practice-specificity-based model (Movahedi, et al., 2007). The best performance, in this model, resulted from ensuring the stress in practice conditions matched the stress of performance conditions. A difference in levels caused the performer to expend extra energy regulating the difference rather than focusing on performance. Matching the stress levels in practice to performance allowed individuals to practice altering their stress to the correct level. However, combat and some police situations may have various levels of stress and the highest levels were too high to place an individual in without risking mental damage. SET allowed the individual to gradually raise stress levels to those of performance and has been used to teach soldiers and police to cope with stress.

Arnetz, Arble, Backman, Lynch, and Lublin (2013) used a combination of the relaxation techniques, guided imagery, and mental practice to train police officers to control stress in an effort to help improve self-regulation as well as overall health. The high stress associated with being a police officer put them at a higher risk for “stomach disorders, anxiety, depression, heart disease, and post-traumatic stress disorder” (Arnetz, et al., 2013). Baseline measures were collected using somatic, psychological, and stress measures of health. They were collected again 18 months after training ended. The training group had significantly better results for general health, stomach problems, use of problem based coping, and vital exhaustion compared to the control group over time. While the training group was improving their scores the control group was getting worse. The training group significantly improved their general health and coping skills compared to the non-training group.

A strategy that is often used in combination with many of the above strategies is deliberate breathing. However, as this intervention is a major focus of the present review, it will be discussed next in a separate section.

Training in Deliberate Breathing

In several of the strategies mentioned previously, deliberate breathing was part of a larger program to train stress regulation. Not only was relaxation impacted by the slowing of the breath, but has been used to counter act autonomic and emotional problems (including anxiety), handle pain, and decrease physical arousal due to a threat (Song & Lehrer, 2003). Consciously altering the breath has been shown to alter the physiological systems thought responsible for the stress response (Song & Lehrer, 2003). This section looks in more depth at the potential for training people to control their rate of breathing as an aspect of self-regulation that may be especially beneficial to performance in general.

Definitions of Deliberate Breathing

A promising area investigated in stress mitigation studies focused on the relationships between breath HRV, respiratory sinus arrhythmia (RSA), baroreflex, PNS and SNS, and stress. Individuals who were trained, through breathing, to control their heart rate variability, and respiratory sinus arrhythmia improved the balance between their sympathetic and parasympathetic systems or in other words, their stress (Peper, et al., 2007). More recently, additional emphasis has been placed on methods that increase the capability of the cardiovascular homeostatic reflexes (such as baroreflex and HRV) such that the individual is able to adapt and recover from high stress situations (Gevirtz, 2013). Higher variability in a biological system is associated with the body's ability to maintain homeostasis and is an indication of resilience and adaptability of both physiological and psychological systems (Napier, et al., 2016; Peper, et al., 2007). The next sections define some key attributes of cardiovascular functioning in more detail.

Heart Rate Variability

Heart Rate Variability (HRV) is the variability in the time between consecutive heartbeats or inter-beat intervals (ChuDuc, NguyenPhan, & NguyenViet, 2013; Heathers, 2014; Kim, Zemon, Cavallo, Rath, McCraty, Foley, 2013; Shaffer & Ginsberg, 2017; Sutarto, et al., 2010). An optimal level of HRV is associated with health, self-regulatory capacity, adaptability and resilience (Jordan, 2012).

Respiratory Sinus Arrhythmia

Respiratory Sinus Arrhythmia (RSA) is a component of HRV. It is represented by the magnitude of the waves on an electrocardiogram (ECG). It works through the sinoatrial node of the heart. It increases heart rate on inhale and decreases it on exhale (Napier, et al., 2016; Sutarto, et al., 2013). The higher the amplitude of the RSA, the higher the variability of the HR. The variability between the slower (exhale) heart best and the quicker (inhale) heart beats can be seen in the amplitude of the RSA on a graph of ECG. The greater the amplitude of the RSA is, the greater the variability between the quickest and slowest heart beats is (Wells, Outhred, Heathers, Quintana, & Kemp, 2012). This serves as the link to the baroreflex through the vagus nerve. The vagus nerve is a PNS pathway to the lungs, heart and digestive track. Input that comes in via the vagal nerve, controls RSA and produces a PNS signal during exhale. This means that when heart rate and breath have a zero-degree phase relationship, HRV and RSA increase at the same time. This generally happens at about six breaths per minute. Lehrer, Sasaki, and Saito (1999) contend that respiration, induced biochemical changes, intrathoracic pressure changes, and vagal stimulation combine to produce RSA. RSA is a measure of the ability of the ANS to regulate stress-activated homeostatic processes in terms of vagal reactivity or the ability of the ANS to regulate and adapt physiological and emotional responses as the need arises with respect to the environment.

Baroreflex

The baroreflex response helps the body maintain blood pressure at constant levels or homeostasis. It does this using a negative feedback loop. Blood pressure increases are picked up by stretch sensors in the carotid artery and aorta (Jordan, 2012). This generates an electrical signal picked up and transported by the vagus nerve to the brain for integration with other signals. The baroreflex responds by decreasing heart rate, which in turn causes blood pressure to drop. The drop is also picked up by stretch sensors and triggers another baroreflex response to raise HR and thus blood pressure.

A well-functioning baroreflex appears to be associated with lower anxiety and depression. This is possibly due to regulation in the medullary brainstem (nucleus tractus solitarius) which communicates directly with the amygdala (emotional control) (Jordan, 2012; Lehrer & Gevirtz, 2014). The baroreflex response makes RSA possible (Shaffer & Ginsberg, 2017).

The baroreflex, HRV, and RSA are all influenced by breath frequency, and are all involved in maintaining homeostasis. As previously mentioned, several interconnected systems work to regulate the body's response to the environment by way of the heart–brain connections and the ANS (Shaffer & Ginsberg, 2017). HRV and RSA are a result of those interactions. This allows HRV and RSA to be used as an indication of the body's ability to respond and adapt to the environment. Although the exact mechanism is still up for debate researchers appear to agree that HRV and RSA can give an indication of the ability of the individual to adapt to their environment.

PNS and SNS Link to HRV

Both the PNS and SNS regulate HRV (Prinsloo, Rauch, Lambert, Muench, Noakes, & Derman, 2011). Increases in sympathetic activity lead to higher HR and lower HRV (Parnandi & Gutinerrez-Osuna, 2015). This is seen under high arousal such as the flight or fight state.

Parasympathetic increases show just the opposite. The heart rate slows down and HRV increases. HRV also shows connections between the ANS and Central Nervous System (CNS) as well as suppression and stimulation of the vagus nerve (Sutarto, et al., 2013). The relationship of ANS and SNS was discussed earlier.

Impact of HRV, RSA, and Baroreflex on Emotional Health

HRV and RSA are related to long term emotional health as well as to the autonomic nervous system's ability to regulate and adapt physiological and emotional responses as the need arises with respect to the environment (Meier & Welch, 2016; Sutarto, et al., 2010). The variability provides the flexibility the body requires to adapt to the environment in real time (Shaffer & Ginsberg, 2017). HRV and RSA and the baroreflex are indicative of the body's ability to effectively regulate autonomic balance, blood pressure, gas exchange, intestines, cardio systems and the diameter of blood vessels controlling blood pressure (vascular tone). They regulate the relationship between the heart, brain and ANS (Sutarto, et al., 2013). They are used to analyze the interactions between the physiological, cognitive, emotional, and behavioral aspects of an individual. Analysis of HRV can point to diseases and imminent heart problems (ChuDuc, et al., 2013). Diseased systems show fewer erratic responses than healthy ones and thus lower HRV. High variability in biological systems is associated with health, self-regulation and resilience.

HRV as a Marker for Psychological Adaptation

High variability in biological systems is associated with health. Higher HRV is indicative of an individual's higher ability to adaptively regulate response both long term and in the moment (Kim, et al., 2013; Prinsloo, et al., 2011). High HRV is associated with higher executive functions such as faster reaction times, correct response on cognitive tasks, attention, adaptability to environment, emotion regulation creativity and higher ability to adjust mental, emotional, and physiological responses to stress (Hansen, Johnsen, Sollers, Stenvik, & Thayer, 2004; Hansen, Johnsen, & Thayer, 2009; Kim, et al., 2013; Prinsloo, et al., 2011; Sutarto, et al., 2013). It is also associated with the emotion "appreciation" (ChuDuc, et al., 2013).

By contrast, low HRV indicates poor adaptability to the environment. The prolonged activation hypothesis states that HRV must be low for long periods of time (such as in chronic stress) to impact health negatively (Verkuil, et al., 2016). While genetics and age contribute to this, psychological stress and physical activity are regulated by the human. Low HRV is associated with anger (ChuDuc, et al., 2013). Low HRV is also associated with worry, decreased positive affect, increased negative affect, and increased tension. Lower HRV is associated with problems with executive function such as higher incorrect responses on working memory tasks, slower reaction times, and lower ability to inhibit reactions when appropriate (Kim et al., 2013). It results in overall lower cognitive function and problems with working memory, errors, and deterioration of set shifting abilities (Prinsloo, et al., 2011). In general, those with emotional disorders such as panic, depression, low attentional ability, poor regulation of emotion and low adaptability to changing circumstances also tend to have low HRV (Kim, et al., 2013).

Effects of Breath Interventions on Stress Response and Performance

Consciously Altering the Breath: Early Studies

Early studies investigated the effects of various deliberate breathing protocols on subjective wellbeing and various measures of cardiovascular functioning. A key finding is that respiratory rates centered around six breaths per minute are found to benefit the cardiovascular system, increase exercise capacity, as well as improve mood, anxiety, and depression (Bernardi, Sleight, Bandinelli, Cencetti, Fattorini, Wdowczyc-Szule, & Lagi, 2001; Gevirtz, 2013; Kim, et al., 2013). This section reviews some key studies.

While researching the feelings of peace and contentment associated with recitation of mantras (typical of yoga) and the rosary, Bernardi et al. (2001) discovered that both caused respiratory rates to fall to 6 breaths per minute. Rosary and yoga mantras were theorized to have matured into their current form because they slowed down breathing to a level that coincided with psychological and physiological benefits.

Song and Lehrer (2003) investigated the biological consequences of seven different respiratory rates on heart rate variability HRV and RSA. This study found that, the slower the respiratory rate, the higher the HRV amplitude (RSA) became, until reaching four breaths a minute. Below four breaths a minute, HRV amplitude dropped. This indicated that reducing respiratory rate helped the person regulate stress levels by allowing them to better maintain balance between the parasympathetic and sympathetic nervous systems or autonomic balance (Shaffer & Ginsberg, 2017).

The cardiovascular and respiratory system were shown to benefit from breathing at 6 breaths per minute (Bernardi, et al., 2001). Several biological functions in the body (i.e. cardiovascular rhythms and blood pressure) operated at 6 cycles per minute. Breathing at the same rate coordinated respiratory and cardiovascular functions that led to the improvements. Breathing at six breaths per minute increased RSA, HRV, improved function of the arterial baroreflex (regulated blood pressure), increased oxygenation of the blood, increased exercise capacity, and helped calm the mind.

Peng, Henry, Lin, Tylova, and Moss (2004) investigated different types of meditative practices on various measures of heart functions. They included the meditative practices of relaxation response, segmented breathing, and “breath of fire”. Eleven experienced meditators were used; however, one outlier was thrown out. Each type of meditation was preceded by 10 minutes of baseline where meditators were told to relax, but not meditate. Relaxation response and segmented breathing resulted in similar breath rates (around 6 breaths per minute), while maintaining different cognitive activities for meditation. Breath of fire involved a respiratory rate of 132-140 breaths per minute. Segmented breathing and relaxation response had many similarities to each other. They both showed significant increases in amplitude of HRV in the low frequency ranges, and significant increases in resonance between the heart rate and respiration compared to baseline. Fire breath produced significant decreases in those measures. The low number of meditators (10) was a weakness of this study, combined with the fact that they may not have been able to control going to a meditative state while relaxing. However, the overall results seemed to match other studies (Lehrer, et al., 1999) in this area.

Wilson, et al. (2006) recommended deliberate breathing as a quick way to alter inappropriate physiological arousal due to stress levels before or during competition. They suggested that slow breathing was a “critical” skill for refocusing the mind when stressed. Breathing quickly (panting) for 10-15 seconds was recommended if arousal was too low. The researchers also suggested focusing on the breath while releasing muscle tension as a way to become centered.

The literature that looked at physiological responses to respiratory rate or cognitive responses all seemed to converge around 6 breaths per minute (it varied slightly per individual) as the most beneficial because it improved cardio-respiratory coordination and helped to calm the mind (Bernardi, et al., 2001). Lehrer, Vaschillo, Vaschillo, Lu, Eckberg, Edelberg, Shih, Lin, Kuusela, Tahvanainene, and Hamer (2003) indicated that participants in biofeedback studies using RSA unconsciously moderated their respiratory rates such that they reduced to around six breaths per minute. This often means that biofeedback that uses resonance breathing, paced breathing, HRV or RSA achieve the same results because they all use techniques that eventually result in the individual breathing around six breaths per minute. Resonance breathing typically ranges from 4 to 8 breaths per minute (Lehrer, Vaschillo, & Vaschillo, 2000). Studies that use paced breathing may have first determined resonance or chosen to pace at 6 breaths per minute. HRV and RSA breathing techniques often involved displaying HRV and RSA with instructions to maximize them by slowing breath down. Sometimes they were combined with a respiratory display or even paced breathing and resonance. Maximum HRV or RSA was achieved by slowing breath to resonance without out an explicit respiration display. The display used for any of these may vary substantially. Some displays included a pacer. Those were often bouncing balls that encouraged inhale on up and exhale on down or lights that dimmed with exhale and brightened with inhale. Some attention to methods and procedures is necessary to realize the psychophysiological benefits of breath control. While single session biofeedback tended to result in more emotional impacts, studies of greater duration than this had more pronounced changes. In a review (Sutarto, et al., 2013) it was found that fewer than 3 sessions were generally not enough to master resonance breathing techniques, but that 10 may not be necessary. It was important to note that that these sessions were typically weekly with home practice in between sessions.

Mechanism Behind Resonance or Six Breaths per Minute

The studies just reviewed demonstrated the benefits for breathing at a rate of six/minute, but further research is necessary to understand the underlying mechanism. The studies reviewed next focused on cardiovascular physiology and its interaction with brain processes.

This ideal state that takes place at around 6 breaths per minute is referred to as resonance or coherence (Kim, et al., 2013). The fundamental idea behind resonances is that one configuration of a system was such that if it was exited or forced at a particular frequency it would respond by producing an unexpectedly large (to the casual observer) response (Garneu, 2017, personal comms). This can be thought of as two masses with a spring connecting them. If one mass was pushed back and forth very quickly, it was forcing that component too quickly for the system to respond. If the opposite happened (too slow) the system followed the forcing function. Somewhere in between was a spot that was ideal for the system that allowed it to respond dramatically.

Vaschillo, Vaschillo, and Lehrer (2006) explained the effects of resonance breathing by way of a closed-loop system model. Oscillations and thus a resonance frequency are produced in closed loop systems when the feedback from the components has a delay. In closed loop systems the resonant frequency is determined by the equation 1/(2D) Hz. D represents the time (in seconds) of the delay. Delay is caused by the volume of blood pumped, blood viscosity, as well as length, volume, inertia, and plasticity of the circulatory system.

Both HR and blood pressure (BP) are components of a closed system, with feedback from either impacting the other. Although the exact feedback time varied from person to person, there is typically around a 5 second delay. This in turn creates oscillations and a resonant frequency of 1/10 or 0.1 Hz (Vaschillo, et al., 2006). Variation in resonance frequency (and thus breath rate) depends on blood volume (Lehrer & Eddie, 2013) with taller people (higher blood volume) having a lower frequency.

When breathing at resonance the baroreflex response is 180 degrees out of phase with HR. Heart rate also has the highest amplitude (RSA) at resonance frequency (Lehrer, et al., 1999; Sutarto, et al., 2013; Vaschillo, et al., 2006; Vaschillo, Lehrer, Rische, & Konstantinov, 2002). This indicates that HR response to baroreflex input is part of the mechanism that increases RSA amplitude.

Over a 10 week HRV biofeedback program Lehrer et al. (2003) found both acute changes during biofeedback sessions and long term chronic changes that improved in the baseline periods from session to session. Immediate boosts in Low Frequency HRV power spectrum and baroreflex sensitivity were associated with resonance breathing. Over time baroreflex sensitivity improved baseline to baseline and became independent of the resonance breathing. Other studies found the same effects and elaborated on those findings. In the short term, for example during biofeedback training, HRV temporarily increased (Vaschillo, Vaschillo, & Lehrer, 2006). In the long term resting baroreflex sensitivity increased. The long-term response was thought to occur because it energized and trained the regulatory mechanisms to perform more easily and effectively in a manner similar to the way athletes trained muscles through exercise (Lehrer & Gevirtz, 2014; Vaschillo, et al., 2006). The body practiced the correct baroreflex response and maintenance of the balance between PNS and SNS. In a long-term study using biofeedback, the baroreflex sensitivity that was initially triggered through RSA and breath became independent of them over time (Vaschillo, Vaschillo, Buckman, Bates, & Pandina, 2010). The enhanced ability in the regulatory mechanisms was thought to lead to more appropriate responses to stress. Emotions tend to be positive and the body seems to be in an ideal state of readiness and relaxation (Kim, et al., 2013).

Brosschot, Verkuil, and Thayer (2016) combined evolution-theoretical reasoning with generalized unsafety theory of stress (GUTS) to suggest a mechanism for regulating stress related arousal. According to both theories the arousal response to stress is the body's default response. They propose that feeling safe interrupts the default response. Unless the interruption took place, the default stress response reacts whether or not there were any real stressors. Feelings of safety trigger the prefrontal cortex (PFC) to suppress the amygdala. If the response is working optimally resting HRV is high. A low resting HRV is indicative of poor suppression of the stress response. Regular dysfunction weakens the system and creates anxiety in the absence of threat, poor physiological regulation, and disease. This is exacerbated by uncertainty that is conditioned to particular contexts. Intolerance of uncertainty of ambiguity is often associated with stress. Chronic worry and rumination tend to prolong physiological responses to stress.

There are many events that if paced at the resonant frequency resulted in high amplitude HR. Successful studies looked at cadences at the resonance frequency for physical loading, gravitational tilting, heat stimulation, presentation of emotion evoking pictures and breath (Vaschillo, et al., 2006). Respiration is convenient to use due to its link to the RSA. Its ability to increase and decrease heart rate allows it to activate the closed loop system and set up oscillations between the baroreflex response and HR.

Breath Control in Performance Settings

The studies reviewed suggested both subjective and objective benefits of breath control. This section reviews studies that focus specifically on contexts in which people performed potentially stressful tasks to test whether breath control benefits generalized to this context. These studies include some that focus on anxiety-reduction, given that anxiety is a source of performance impairment. However, studies reviewed next did not directly test for effects of breath control on quality of performance.

Breath Control as an Intervention for HRV, Anxiety and Stress

HRV/breath biofeedback was used on 20 male athletes to see if it could reduce anxiety and increase self-efficacy (Dziembowskal, Izdebski; Rasmus, Brudney, Grzelczak, Cysewsk, 2016). Anxiety was associated with injury and performance decrements in athletes. They did not test for performance impacts. Both a control group and test group were used although as this was a pilot study the N was small. The training group had ten, 20-minute sessions over three weeks. While anxiety scores for the training group decreased significantly there was no change in self-efficacy. The control group showed no changes at all.

The reduction of managers' psychological and physiological stress caused by work pressures was the subject of a study using breath and HRV/RSA feedback (Munafo, Patron, & Palomba, 2016). Sixteen managers were assigned to a training group and the remaining fifteen into a control group. The training group had five weekly training sessions lasting 45 minutes each. There was no practice in between. A display of the participant's heartbeat was overlaid on the participant's breath signals. They were told to breathe slowly until they were able to get the signal waves form the breath and the heartbeat to align in phase with each other. The control group wrote in a stress journal daily. All participants were given pre and post state-trait anxiety inventories, a 36-item short form health survey that looked at physical, emotional, and social functioning, blood volume pulse, blood pressure, and skin conductance levels. Both groups reduced resting heart rate, lowered anxiety, and improved in health-related quality of life. Only the training group increased RSA, decreased skin conductance, and decreased systolic blood pressure. They also had lower emotional interference compared to the control group. This result was not as strong as some of the other training programs. The control group wrote in their journal every day. The training group did not practice between sessions. It was not clear if a practice requirement would have changed any of the results.

Paced breathing at six breaths per minute for ten minutes was compared to self-paced walking, and a control condition consisting of quite study, to compare differences in anxiety and affect

(Meier & Welch, 2016). Thirty-two college students with high perceived stress took part in this within subject study. All interventions lasted ten minutes. There were counter balanced and took place on separate days. Pre and post-test measures as well as a second post fifteen minutes later were used. Both walking and breathing significantly reduced however, breathing reduced it more (moderate effect size vs. small). In addition, breathing had a significant temporary increase in calmness, while exercise had a significant temporary increase in energy that disappeared by the second post-test. All conditions significantly increased HRV. Tension scores were significantly lower throughout the exercise and biofeedback compared to quiet study. Change in HRV after exercise was moderately associated with an increase in tension and tiredness after exercise.

Wells, et al., (2012) focused on musicians who as a group tended to have higher levels of anxiety than the general population. A single 30-minute session of paced breathing was used to examine effectiveness in decreasing musical performance anxiety. Forty-six musicians were divided into three groups. Two groups had interventions and while one group acted as a control. All participants took a baseline STAIS-S, and had five minutes of resting state HRV measured while seated, palms up and eyes open. This was followed by an anticipation phase meant to create stress. The musician was given a technically difficult piece of music to review for five minutes. They were told that their performance would be recorded and watched, they would be evaluated on accuracy and musical interpretation. The next phase was performance. They were reminded of interpretation and accuracy and additionally told not to stop in case of a mistake. Once done they completed another STAIS-S. At this point participants were given the interventions. Due to the short nature of the study resonance rate for each participant was not achieved. Instead participants in both intervention groups used a display that paced their breaths to 6 breaths per minute with a longer exhale than inhale. The group with biofeedback had two additional displays they could watch. One displayed HR while the other indicated high or low HRV with color coding. The control group read during the training time.

After the intervention the musicians were given another anticipation and performance phase. The musical piece was counter-balanced, but otherwise the session was the same. This was followed by another STAIS.

High anxiety performers in both intervention groups had large reductions in pre to post intervention anxiety scores. Low anxiety individuals in the intervention groups remained low post-intervention. Responses were significantly different to the controls. This study analyzed high frequency (HF) and low frequency (LF) in the ECG power spectrum. Intervention groups had greater increases in HF and decreases in LF/HF ratio than the control group. This may have indicated more PNS activity while under stress. The study did not report on performance effects.

Lending support to this area was a meta-analysis (Goessl, Curtiss, & Hofmann, 2017) of HRV biofeedback impact on stress and anxiety in both clinical and non-clinical populations. Their analysis showed both stress and anxiety levels dropped after treatments. Both the within group and between group analysis showed large average effect sizes and significant p values. The results held even when number of females and number of sessions were controlled for. It also occurred whether state or trait anxiety was used and various measures of stress. The HRV biofeedback also appeared to work equally well whether the population was clinical or non-clinical.

Summary of Breath, HRV, Anxiety, and Stress Studies

Generally, the anxiety/relaxation studies using breath were successful. They were able to reduce anxiety even in as little as one session so long as they had a simple technique to use to learn. Some studies also saw increases in calmness, HRV, RSA and health related quality of life while there were also decreases in skin conductance, lowered emotional interference, and lowered blood pressure. These were all indications of lowered stress and anxiety. Small sample sizes and inadequate practice may have limited observed benefits of the intervention in some studies.

Breath Control, HRV, and Performance Enhancement

Thus far, it has been argued that controlled breathing elicits benefits to the person that may be evident in performance contexts. The next question to be answered is whether these benefits are accompanied by objective performance improvements. Evidence on this question comes from two sources. The first is research on whether HRV is actually linked to performance quality, in studies observing variation in HRV response to stress or training procedures such as exercise. The second comes from studies that manipulated HRV via breathing and tested for performance change. This performance may be cognitive, physical, or both. They have used a variety of methods and intervention parameters such as varying lengths and number of training sessions.

The following sections look at some of those studies in more detail, considering each of the two sources of evidence in turn. Given that studies utilize a variety of methodologies, discussion will also look at strengths and weaknesses of those methodologies and their implementation in individual studies.

HRV and Cognitive Performance

Since research indicated that HRV and its associated RSA are indicative of better ability to maintain homeostasis, the next question asked was whether HRV is correlated with performance. The major issue with these types of studies, reviewed next, is that they use a median split to separate subjects into high and low HRV. High and low HRV is not defined relative to an absolute standard in any of the studies and there is nothing to indicate that high in one study is not low in another. Furthermore, because HRV is measured but not manipulated, results may reflect correlates of HRV such as cardiovascular health, rather than a direct impact of HRV on performance.

Correlations of HRV with cognitive function were investigated in participants experiencing dental anxiety (Johnsen, Thayer, Laberg, Wormnes, Raadal, Skaret, Kvale, & Berg, 2003). A small sample of individuals with severe dental anxiety were tested to see if having higher or lower HRV was associated with performance on a selective attention task while they felt threatened. Participants who did not expect dental care on the same day had an hour-long interview and then a five-minute baseline to determine HR, HRV, and skin conductance level. Then they moved to a dental exam room and while seated in a dental chair viewed nine scenes of various dental procedures lasting around two minutes each. This was followed immediately by a Stroop test. Responses were recorded on a keyboard while the participant verbally gave their answer. In addition, threatening dental words and neutral words were colored in a modified

Stroop to test attentional bias. After completing the Stroop, participants had five minutes to recover. All participants had longer reaction times on incongruent color words and when words were threatening. The low HRV group had longer reaction times than did the high HRV group on those same categories. The high HRV appeared to be associated with better regulation despite similar responses on various anxiety scales. All participants had increased HR and decreased HRV during film and Stroop. These did not return to baseline during the recovery. The skin conductance showed increased activity during the film and Stroop but did decrease in recovery indicating it may be controlled by a different mechanism.

A criticism of this study is that there was not a true control in the form of a non-anxious group. However, there are several other studies that seem to get similar types of results with anxiety. An additional criticism is the use of a median split. The paper does not indicate what values defined high or low HRV and if those numbers tend to match those in their other studies.

Hansen, et al. (2009) used 53 sailors to determine the relationship between vagal tone as measured by HRV and working memory and attention. More specifically they were interested in the executive control aspects of working memory. Executive control was involved in planning subsequent behavior, making decisions, as well as analyzing and correcting problems. Strategizing and sustaining focus were important components of these abilities.

The cognitive tasks involved a continuous performance task and a working memory task. The continuous performance task consisted of 315 trials and was broken down into the following subtasks and measures:

- Simple reaction time - This is a non-executive control task. Participants pressed a key as fast as possible when a number appeared on the screen. Only numbers were displayed. This produced a baseline reaction time.

- Choice Reaction time - Participants were to press a key only if the number seven appeared. This was a non-executive task.

- Serial pattern matching 1 - The participants pressed a key if two identical numbers were presented in a row. This involved a maintaining memory of the number sequence that had to be updated, and so this was an executive task.

- Serial pattern matching 2 - The participants were asked to press a key when the numbers increased sequentially.

Dependent measures consisted of reaction time, correct responses (true positives) and incorrect responses (false positives). The working memory task consisted of pressing a key if the target on the screen appeared 2 targets previously. Four blocks consisting of 50 targets each were provided. The same dependent measures as the continuous performance task were used. HRV and HR were measured. Participants were split into high and low HRV on a median split determined during baseline.

On the continuous performance task with all the subtasks pooled the high HRV group had faster reaction time (RT) than the low HRV group. Once the subtasks were differentiated, the high

HRV group had faster RT on serial pattern matching 1 (executive) than low HRV group. In the working memory condition, there was a positive correlation between resting HR and RT on false positive responses. The high HRV group outperformed the low HRV group on the working memory task in terms of accuracy for tasks involving executive function. The high HRV group outperformed the low on the continuous performance task in terms of reaction time and accuracy for tasks involving executive function.

Hansen et al. (2004) expanded the previous study by using a train/detrain paradigm to study the relationship between fitness, HRV, and cognitive function in 37 male sailors. During the initial phase all 37 sailors participated in 8 weeks of physical aerobic training. Training was followed by pre-test cognitive and physical assessments. The group was then split in two and assigned to either a training group or a de-training group. The detrained group was sent out on a ship for duty. They did not do any aerobic exercise but did move around and performed tasks requiring anaerobic muscle work. This was the de-training phase because they did not continue the aerobic training of the previous 8 weeks and thus had a decrease in fitness level. The trained group remained on land and continued the aerobic training program for another four weeks. Once the de-trained group returned to land, both groups were assessed on the same cognitive and physical tasks. The cognitive tasks matched those in the Hansen et al. (2004) study. Physiological measures consisted of VO2 max (maximum volume of oxygen used during exercise that is increasing in intensity) and resting HRV. At pretest there were no differences between the groups in terms of VO2 max, HRV, continuous performance task performance, or working memory task performance. After four weeks of the intervention (training or de-training) there were significant differences in the two groups on multiple outcome variables.

The training group increased their HRV and VO2 max. Their performance on the tasks involving executive functioning increased as well. Their RTs were faster, and they had more true positives. The authors attribute this to learning. Their performance on the non-executive task remained stable.

The detrained group had a decrease in VO2 max and HRV, both of which were also lower than the trained group. They showed decreased performance on executive tasks. They bettered their performance on RT on the non-executive task. The authors suggested that a lower HRV may have indicated the de-trained group was more stressed. They pointed out that past research has shown stress associated with an increase in performance on simple tasks while decreasing performance on more complicated tasks.

Hansen et al. (2009) split 60 sailors into two groups, either high or low HRV. Then they were placed into threat of shock or no threat conditions to make a total of four groups. The intent of this study was to discover how the threat of shock might impact the relationship between HRV and cognitive function. Cognitive tasks were identical to those of Hansen et al. (2004).

The participants who had high HRV consistently performed well whether they were under threat or not in terms of reaction time and accuracy. This was expected as high HRV has been associated with functioning of prefrontal cortical areas involved in attention regulation, adaptability, and inhibition of inappropriate pre-potent responses. The authors suggested they would be more likely to adapt to threat by attending to the task rather than the threat.

Generally, the high HRV group outperformed the low HRV group in the non-threatening condition in terms of accuracy on the continuous performance task and working memory subtasks. Under threat the low HRV group's performance on accuracy improved significantly and often equaled performance of the high HRV group. The authors suggested that fear may have increased attention and processing power in the low HRV group, or that worry, or other emotions associated with ow HRV may have served as motivation. They emphasized the need to look more closely at individual differences in personality traits.

The authors suggested the faster reaction times of the low HRV group for the simple reaction time and the true positives on the working memory task compared to the high HRV group, should be looked at in context. The high HRV group's reaction time (measured in milliseconds) may reflect the extra time taken to inhibit a response, or even the low HRV group's tendency towards impulsiveness, or the low HRV group's response to the instructions emphasizing penalties for time. The fear of penalty (shock) may have proved too hard to inhibit and thus impacted motor functions. This may be important to keep in mind for professions such as military and police. The extra milliseconds taken by the shooter may be critical to prevent shooting an innocent person.

Since specific personality constructs were not accounted for, only suggested as being related to low HRV, the question remains, as to which or all of those relate to performance and what role motivation played.

Another study supporting the role of HRV in executive function performance, specifically attention, looked at resting RSA (normalized) and its relationship to attention (Kaufmann, Vogele, Sutterlin, Lakito, & Kubler, 2011). Resting rates of RSA (normalized) were found to be a good predictor of performance on a brain computer interface involving executive function skills. As RSA normalized increased so did performance, with RSA accounting for 25.6% of the variance in performance. This indicated that parasympathetic control probably contributed to sustained attention.

Although the interface was tested by 34 participants with normal function, it was designed for people with serious deficiencies in their speech and voluntary muscle control. A matrix with letters and numbers was displayed to the person. Each character had a unique number of flashes associated with it. The participant spelled out words by sustaining focused attention on the desired character while ignoring the flashes of characters around it.

Another study looking at the association between HRV and cognitive performance used a threat cue (the color red) vs a neutral color to see if even subtle threats had an impact on HRV and thus cognitive performance (Elliot, Payen, Brisswalter, Cury, & Thayer, 2011). First participants took an IQ test followed by HRV measurements, then the cue as appropriate to condition, HRV measurements and then another IQ test. The threat cue caused the baseline high frequency HRV (or RSA) to drop from the first to second measurements. That drop was reflected in a drop in their subsequent IQ scores.

Haller, Raczkevy-Deak, Gyimesisne, Szakamary, Farkas, and Vegh (2014) used 119 experienced police officers to look at the relationship between the decision to used aggressive behavior and HR and HRV. Officers were paired into teams and randomly assigned to one of four scenarios. Only the first two scenarios were reported on in this study. Both reported on scenarios in which the pairs of officers were informed that there were noises coming from an unoccupied apartment. Both pairs of officers walked into what appeared to be an apartment building hallway. The apartment door they were to enter was slightly ajar. This was the opening phase. From this point onward, the scenarios were different. As officers entered the apartment the active phase began.

In scenario one the officers were confronted with a scene that indicated a robbery was in progress. They were immediately confronted by the first burglar and later ambushed by the second. The burglar was aggressive and non-compliant. In scenario one, officer aggressions such as punching, kicking, and gun use were justified and appropriate. Aggression was purposely provoked by the actions of the actors plying the burglars.

The officers in the second scenario could hear all the commotion and shooting in the first scenario. This was done to increase the likelihood of aggression from them. Scenario two did not involve a crime. The scene appeared to be people moving into the apartment. Officers were greeted by two men who identified themselves as journalists. The journalists appeared to be nervous about police presence, however, provided identification, proof that they were journalists, and tried to contact their embassy. Physical aggression on the part of the police here was unprovoked and not appropriate.

HRV was recorded from before the scenario began until after it ended. HRV was calculated using Root Mean Square of Successive Differences (RMSSD). During scenario one, in which officers were provoked, appropriate aggression and appropriate gun use in the active phase was predicted by low HR and high HRV in the opening phase of the scenario, before the officers could determine if a crime was being committed or not. It also marked a reluctance to surrender when faced with impossible odds. The authors felt perhaps this was a mark of resilience although there was some debate as to its meaning. During scenario two, unprovoked, inappropriate aggression and gun use was predicted by high HR and low HRV in the opening phase before officers could determine no crime was being committed. Lack of aggression (the correct response) was marked by low HR and high HRV in the opening phase. HRV did not tend to change from opening phase throughout the scenarios. It appeared the inclination towards aggression was made before information that could counter it could be gathered. Those with higher HRV appeared to make more appropriate decisions about use of aggression. They may have picked up on the cues that would indicate what was going on better than the Low HRV group. This study like several of the previous did not define high and low HRV.

Summary of HRV and Cognitive Performance Studies

The studies comparing high versus low HRV groups were interesting for several reasons. They generally found that performance on executive tasks was related to higher resting HRV, RSA, and lower HR. In at least one study, this appeared to carry over into an anticipatory phase prior to decision making under stress. There were a couple of exceptions having to do with reaction times. It is possible that in some instances those reflect those with higher HRV taking the time to suppress inappropriate responses or the extra time needed by system two. They were all flawed using a median split as it was impossible to tell if high HRV in one study was equivalent to high in another.

The study involving using the color red as a threat was informative because even something minor was able to adjust HRV and then cognitive performance (Elliot, et al, 2011). This study combined with the considerably more threatening police study (Haller, et al., 2014) indicated that some sort of intervention that would help buffer physiological responses to stress would be helpful to achieve better cognitive performance.

Given that HRV is associated with executive control performance and that it can be adjusted with exercise (or lack of exercise), or even temporarily with colors, the next step is to show that it can be adjusted using breath. Other papers have stated that other techniques could work as well. Breath is of interest as manipulations are convenient, available, and already associated with relaxation techniques.

Breath Interventions to Adjust HRV and thus Cognitive Performance

The studies reviewed in the preceding section for the most part link higher HRV to superior cognitive performance. Next, studies that directly manipulated HRV with the aim of improving performance are discussed.

Parnandi and Gutinerrez-Osuna (2015) used biofeedback in a video game to teach participants how to regulate their stress levels. Participants had physiological stress monitored and measured in game by electrodermal activity, heart rate variability, or breath rate.

The game increased in difficulty for players whose arousal was over baseline and increasing. It also gave cues to help players regulate their stress such as breath rate, and colored arrows to indicate increasing or decreasing arousal. In addition to the three biofeedback groups, a deep breathing and a control group were added. Each group had five participants. All the participants' baseline consisted of two minutes of 6 breaths per minute (or 0.1Hz) paced breathing. This should have been around resonance for the participants, but it may have confounded later results as the researchers effectively gave everyone a short resonance intervention that may have impacted anxiety or performance on the Stroop pretest. Directly following baseline, a Stroop was given to assess performance in response to stress. The key to press for a response moved randomly at the bottom. The participants were aware of their scores.

The participants were divided into a breathing rate game biofeedback group, an HRV game biofeedback group, an electro-dermal biofeedback group, a deep breathing group, and a game only group. After baseline four of the groups played the game for eight minutes. The deep breathing group did not. They continued to breathe using the baseline paced breathing with an inhale of four seconds and an exhale of six seconds. The control group did not receive any feedback during the game. After the game participants repeated the Stroop test to see if any stress regulation skills had transferred. While biological signals changed for the groups that focused on breathing, the performance on the Stroop tests did not increase in a way that would indicate it was anything other than a learning effect. This probably shouldn't be unexpected due to the short nature of the intervention and the type of display that focused on breath. The deep breathing and the breath feedback interventions had the best results for relaxation.

Sherlin, Gevirtz, Wyckoff, and Muench (2009) created a study to look at the impact of a short (15 min) active RSA biofeedback protocol on participants scoring at least 1 SD above the mean on a Perceived Stress Scale. The intent was to see if a minimal intervention was able to achieve a reduction in anxiety and if that was enough to improve performance. One hundred twenty-one participants were whittled down to a sample size of 46 through a host of exclusion criteria. RSA biofeedback was achieved by use of a monitor that eventually caused the participant to achieved resonance. The control group watched a monitor of their HR (smoothed) and were told to release negative thoughts. The RSA group was given points for successively using the biofeedback device to achieve resonance. A Stroop was administered before and after the treatment. Anxiety (by way of the STATE Trait Anxiety Inventory- State form STAI-S), HR, and performance were assessed.

Both groups significantly reduced anxiety scores. The RSA group had significantly more reductions (20 out of 20) than did the control (5 out of 20). The largest difference between the two groups appeared in the calm, content, and ease categories. Points earned by the RSA feedback group negatively correlated with anxiety scores. This indicated that correct practice was important to end results. The Stroop test did not result in significant performance differences between the experimental and the control group. The RSA group trended towards greater improvements than the control.

This study did not have the RSA group practice enough during training, and 30 percent of the RSA group were unable to correctly use the biofeedback device at the end of training. It may be that with proper training, the results in performance categories trending towards significance would have achieved it.

A single ten-minute session of RSA biofeedback was investigated on 18 self-identified stressed men to see what impact it had on cognition (Prinsloo, et al., 2011). All participants came in the week prior to the experiment to learn their particular biofeedback mechanism. The RSA group had a biofeedback device that displayed their RSA. They were taught how to breathe to maximize RSA. This technique should put them close to their resonance frequency. The control group used a similar device but instead saw their smoothed HR on a screen. They were told this was their blood density. They were told to focus on it and release negative thoughts. Both groups practiced for 10 minutes. Once they arrived for the experiment participants completed questionnaires, a baseline of BP and HR, received a reminder of how to use the biofeedback device and then took a modified Stroop. The leads were attached followed by a rest period and then the intervention for 10 minutes. This was followed by another rest, Stroop, and questionnaires. The Stroop consisted of colored words that were always incongruent with the color of ink, color words written in gray ink, and white boxes. The participants were to indicate the color of ink on the colored works, the name of the color written in gray ink, and count the white boxes.

Pre to post comparisons showed no difference on performance accuracy for the colored or gray words for either groups. The white square counts showed a significant difference. The control groups counting errors were the same pre and posttest. The RSA feedback group had a significant reduction in count mistakes. The participants in the feedback group did not make any mistakes after the intervention. Both groups had improved reaction times pre to post. The RSA feedback group's reaction time was significantly better than the control group on both color and grey words without sacrificing accuracy. Although respiration rates were reduced in the RSA group during treatment both groups had similar respiration during the Stroop.

These results indicated an improvement on several executive function tasks including working memory updates, mental set shifting and inhibition of responses. Updating working memory was addressed by counting squares, the shirt can be found when participants changed from counting squares to responding to colors words and inhibition is tested by responding to the color and not the word. The variability of performance for the experimental group decreased after the intervention while the control group increased. The authors suggested the combination of changes indicated more focus on the part of the experimental group. In addition, the HRV biofeedback group reported feeling less anxious and sleepy than the control groups.

Sutarto et al. (2013) designed their study to include 5 weekly sessions of resonance breathing sessions using the protocol designed by Lehrer et al. (2000) on 36 females. The goal was to improve the cognitive function of women working in a factory. Cognitive improvements were thought to be protection against accidents. Before the intervention both the experimental and control group took a physiological baseline consisting of four minutes of rest, two minutes of stress, and 4 minutes of recovery. These were followed by cognitive tests aimed at attention, memory and cognitive flexibility (or executive function).

Participants in the attention task used both selective and sustained attention in a timed event while taxing the speed of their information processing. The goal was to find and tag as many of the designated letters as attainable in the time allotted. Working memory was assessed by showing the participants four numbers. This was followed by a single number display. Participants indicated if the single number had been in the set of four numbers. Accuracy and RT were recorded.

Executive function or cognitive flexibility was tested using a Stroop test. More specifically attention and the ability to inhibit or change responses were tested.

Each session lasted 30-50 minutes and the participants were asked to practice at home as well for 20-30 minutes daily. During the five training sessions physiological data were recorded consisting of HRV total power and breaths per minute.

In the first session the feedback participant's resonance breath frequency was determined. A bouncing light was used to pace the women to breathe at several frequencies. They were to breath in as the light went up and out as it went down. HRV was measured while the participant breathed for 2 to 3 minutes each at 6.5, 6, 5, and 4.5 breaths per minute. Care was taken to not hyperventilate. Once each individual's resonance was discovered, they used that particular rate for all formal biofeedback and home practice sessions. During sessions 4 and 5 the women were given math problems to do while breathing. The control group did not practice anything at home. They came into the testing area and sat in front of a computer five times for 20 minutes each. At week 6 they took the cognitive tests again.

As training progressed HRV for the biofeedback group increased while HRV for the control group decreased. The biofeedback group significantly improved their attention, memory and executive function. Both groups improved attention; however, only in the biofeedback group was the improvement significant while the control group showed only a nonsignificant trend. The biofeedback group had a significant improvement on the memory task while the control did not. The biofeedback group also had an improvement on the Stroop task.

A study was conducted to test the effectiveness of resonance breath biofeedback to impact HRV and thus cognitive performance for female manufacturing operators (Sutarto, et al., 2013). In addition to a pretest baseline and a posttest there were five weekly training sessions. The first meeting established physiological and cognitive baseline. Four minutes were used recording an HRV baseline. This was followed by the participants counting backwards from 100 by seven for two minutes. This was to act as a stressor. There was another four minutes for recovery. After this the participants took three cognitive tests. A Stroop test was taken to provide a baseline for cognitive flexibility, the Sternberg test to provide information on working memory, and finally a test of attention to establish selective and sustained attention. A week after the final training session a post test was taken that was identical to the pretest.

In between the pre and posttest there were five training sessions lasting 30-50 minutes each. These were based on Lehrer et al. (2003) protocol. In the first training session the individual's resonant frequency was established. In between session the participants were to practice breathing at their resonant frequency for 20 minutes day for 5 minutes at a time. The second and third sessions focused on techniques to help maintain resonant frequency. In the fourth and fifth sessions the participants had stress introduced in the form of mental math problems. In order to see if the training was working the percentage of total HRV that moved from the HF to LF range was assessed.

The group that received training had significant improvements in cognitive performance from pre to post on all the measures. This was the Stroop test interference score, the Sternberg response times, and the concentration score on the test of attention. The control group showed no improvements.

This study was limited in that it only included females and due to dropouts, there were only nine in the training group and seven in the control group. Another study followed this with an almost identical protocol except that that the N was increased to 36 females.

Summary of Breath Interventions to Adjust HRV and thus Cognitive Performance

Two of the papers (Parnandi & Gutinerrez-Osuna, 2015; Sherlin, et al., 2009) only had a single session of training. While both reported improvements to anxiety, relaxation, and other related mood impacts, neither had an impact on performance. Sherlin et al. (2009) noted that many of their subjects could not effectively achieve resonance in such a short practice time. Another study (Prinsloo, et al., 2011) claimed to have one session; however, there was a practice session to learn to use the biofeedback before the testing. This extra practice may have impacted performance as this study reported performance improvements in working memory, mental set shifting, and inhibition of responses. It also had improvements to reaction time without sacrificing accuracy. It should be noted they all practiced at six breaths per minute not their specific resonance. The next two studies (Sutarto et al., 2010) increased practice substantially. Both used five weeks of practice protocols that had weekly formal session and daily practice. These two were able to show changes to baseline HRV. This was accompanied by cognitive performance changes such as improvements to attention, concentration, memory, and improvements to Stroop performance, and response time. These performance results were consistent with those from studies in which the groups were only separated on high and low HRV. It appeared that the training was important to create the HRV effects associated with the performance changes.

Breath Interventions to Adjust HRV and thus Physical Performance

Other studies using breath, HRV or RSA biofeedback brought in additional physical aspects to tasks. A case study involving shooting was included due to shootings applicability to high stress professions such and the military and police.

Physical performance and anxiety were assessed in a case study involving shooting. Performance and anxiety were on the list as areas that could use more work. A single female Olympic trap shooter was assessed to determine if resonant frequency breathing could help her control her negative thoughts and physical reactions during competition (Gross, Shearer, Bringer, Hall, Cook, & Kilduff, 2016). She had more difficulty in the minute between shots if she had missed a shot or there was a target malfunction. She had been replacing negative thoughts with a song but was unable to get it to consistently work. The study was designed to teach her resonant breathing and give her a biofeedback tool to use to practice at home so that eventually she would be able to resonant breath on her own, in competition, and without a biofeedback device. The formal sessions were spaced out into four days. Day one established her resonance frequency breath. Day two was 28 days later. She had several tests of her ability to maintain RF without biofeedback. Actual biofeedback sessions were sandwiched in between. Day three was 61 days later. This included resonance frequency tests to simulate how she would incorporate them into her competition. On Day four (98 days later) the shooter performed in a simulated competition where resonance frequency accuracy and shot accuracy were recorded. The shooter's compliance with home practice increased throughout the year. Improvements were seen in accuracy of resonance frequency and increased cardiovascular effects typical of the intervention.

Performance data for actual shooting were not recorded. The authors followed up with her 349 days later. Shooter reported being able to use the technique in competition and feeling calmness. She used it after a missed shot and was able to hit the following one. She indicated her score has improved by 1 target per round. There were three rounds with 25 shots which determined which six shooters proceeded into the final round. The shooter claimed that three shots per competition would make the difference to getting into the final round. Authors suggested formal studies to include a pre-intervention baseline measure of emotional regulation and performance measures on the task.

Success with neurofeedback with professional musicians led to an exploratory study that attempted the same technique on dancers and compared it to HRV biofeedback and a control (Raymond, Sajid, Parkinson, & Gruzelier, 2005). Following unexpected dropouts, the study finished with six dancers in the neurofeedback group, four in the HRV biofeedback group and eight in the control group, which made it fairly weak. Dancers were from the Imperial College Dance Sport Team. Dancers were video-taped pre and post intervention. Researchers also recorded the amount of practice dancers engaged in so that it could be controlled. Video were sent to two professional judges (blind to condition) for ratings. The ratings methodology came from a standard scale used for national dance assessments. It included technicality, musicality, timing, partnering skill, performance flair, and overall execution.

The alpha/theta neurofeedback consisted of 10, twenty-minute sessions over four weeks that were designed to increase theta while decreasing alpha. Specific events that triggered a decrease in alpha waves and an increase in theta waves were thought to be good for cognitive and memory performance (Klimesch, 1999). Participants were encouraged to relax deeply while listening to either a babbling brook or waves breaking on the shore. The brook indicated alpha waves dominated while the breaking waves indicated that theta dominated while in theta the participants visualized themselves dancing as they wanted to. Care was taken to ensure participants did not sleep through the sessions.

The HRV biofeedback group also received 10 sessions each lasting twenty-minutes over four weeks. The HRV biofeedback group determine resonance breath using the Lehrer, et al. (2000) protocol. The control practiced as normal.

All groups improved in ratings of dance performance with practice. Both feedback groups improved significantly more than the control. The feedback groups were not significantly different from each other in overall execution. Differences emerged between the biofeedback groups in the subcategories. The neurofeedback group had significantly more improvement in the timing subscale compared to the control, while the HRV group had significantly more improvements than the control on the technique scale.

Gruzelier, Thompson, Redding, Brandt, and Steffert (2014) followed up on the dance exploratory study comparing neurofeedback to HRV biofeedback and a control condition with dancers in this study. They made several changes. The study added a fourth intervention in the form of a choreography class. They had 64 first year dance students. Several cognitive tests were added including cognitive creativity, a mood questionnaire, and a personality assessment that looked at neuroticism/anxiety, extraversion, agreeableness, conscientiousness, and openness to experience. The goal of the neurofeedback was to produce more theta waves in comparison to alpha waves. The dance videos in this case were only 40 seconds long which the authors felt in retrospect may not have been long enough to really see differences in performance. The HRV group showed learning session to session. They also had a significant decrease in anxiety compared to the controls. The neurofeedback, choreography and control group all had increases in anxiety. The reductions in anxiety experienced by the HRV group were associated with significant improvements in artistry and technique scores. The neurofeedback group was much slower to pick up the technique than previous experimental groups. The authors suggested this was due to group sessions as opposed to individual sessions. Perhaps with more practice the results would have matched the exploratory study better. They had a greater increase than the control group on the elaboration subscale of the cognitive creativity assessment, but they were not associated with overall performance. The authors also pointed out that in the exploratory study several of the dancers had higher theta to alpha ratio to begin with and that may have impacted scores. Interestingly in both studies HRV training showed benefit.

While Hansen et al. (2004) focused on showing how detraining HRV impacted performance, another study looked at how increasing HRV of already fit athletes impacted performance (Choudhary, Trivedi, & Choudhary, 2016).

Choudhary et al. (2016) conducted a study on 24 state or national level 5 k runners using HRV biofeedback that produced resonance breathing in the experimental group. The authors' goals were to see if the HRV biofeedback lowered total stress levels of the runners, how it impacted their HRV, VO2 max, heart rate, and respiratory rate, and to determine if those changes would be accompanied by faster times on their races. Runners had physiological measures taken at baseline. Stress was measured using skin conductance. Participants in the experimental group followed Lehrer, et al.'s (2000) 10-week protocol to establish their resonance breath rate and training. They had weekly "official" biofeedback sessions where physiological measures were taken. In between they used a device twice daily for twenty minutes to practice resonant breathing. The control group practiced running as normal. After 10 weeks all measures were repeated. The experimental group had significant changes on all measures where the control group did not. They were significantly different than they control group stress reduced, HRV increased, LF/HF ratio increased (indicating sympathetic to parasympathetic control). VO2 Max increased, and running times decreased. Importantly for runners the time reduced was not just statistically significant. It was significant for the race outcome. The control group's mean run time was 18.24 minutes at pre and 18.11 minutes at post. The experimental groups run time reduced from 18.27 minutes to 15.89 minutes.

Summary of Breath Interventions to Adjust HRV, and Performance Enhancement

Studies reviewed in this section showed improvements in physical performance. The type of performance differed per study. It ranged from gross movements of running to fine-tuned movement of shooting to more theatrical and complex movements associated with dance. The studies also had relatively long practice times in terms of the number of weekly sessions. This feature allowed the observation of improvements session to session.

Breath Interventions to Adjust HRV and thus Both Physical and Cognitive Performance

Bouchard, Bernier, Boivin, Morin, and Robillard (2012) conducted a study to see if practicing stress management techniques while performing a stress inducing game would result in lower stress and higher performance of a different task. Forty-one male soldiers were used. They had all had basic classroom stress management training and basic first aid in combat. On day one participants spent 15 minutes in a stress management class to refresh their memories. The class focused on tactical breathing. This involved inhaling for a count of 4 holding for a count of 4, and then exhaling for a count of 4, then holding again for 4 before starting the cycle over. Participants in the control condition then left and did not' return until day 5 for final testing. The 3-day training for the experimental group allowed the participants to practice tactical breathing while slowly increasing the difficulty of the game. The game consisted of a two-member team, in different rooms, playing Left 4 Dead (zombie apocalypse). During the game biofeedback was provided on the display while team members attempted to protect a third virtual team member. Baseline physiology was collected for two minutes every day. As arousal increased (as evidenced by HR and skin conductance) a red texture progressively covered the screen, although it never fully covered the screen. The sound of a pumping heart could be heard that responded to increased arousal by getting faster and louder. Coaches were present in the sessions to run the session, provide guidance on places tactical breathing might help, and adjust the game difficulty and feedback in real time. After training completion both the experimental and control groups were tested in a live simulation on medical determining and administering medical care for an ambushed soldier.

The live action test began on day 5 with an anticipation phase where the soldiers were briefed on their mission. Once they were briefed the scenario started with an Improvised Explosive Device (IED) explosion. They saw an actor representing an injured soldier. The soldier had a severe wound to the head, chest, arm, and leg. The room was filled with smoke. The actor portrayed himself as if in severe emotion and physical pain. A second IED exploded during the event. The test lasted 10 minutes. The tasks were to:

1. Check the area for safety,
2. Check breathing and treat as necessary,
3. Check circulation and treat as necessary,
4. Determine correct treatment for a chest wound,
5. Execute proper treatment for chest wound, and
6. Keep track of wounded soldier condition and respond accordingly.

On day 5 there was a significant difference between groups in stress as measured by cortisol. The experimental group was far less stressed. Heart rate showed the experimental group had lower stress when comparing baseline to apprehension phase. Measures of self-efficacy pre to post did not change for either group. There was one significant difference in performance. That was determining the appropriate treatment of the chest wound. The authors noted two other tests that were trending towards significance: responding accordingly to the wounded soldier's condition and perfect success on the medical test.

While the results indicated better performance on one task and a trend toward it on two others there were several elements of the design that make it difficult to tell which aspect of the design (or combination) created the results.

The control group had training as usual on day one and then came in for the final task on day 5. The experimental group received training for three consecutive days. The control probably should have practiced tactical breathing during that time, while not stressed or done the event right away.

During training the coaches adjusted the biofeedback in real time to better help each participant. They did this by adjusting the sensitivity and weighting of the results of galvanic skin response and heart rate. This means a participant did not get the same treatment. The fact that the coaches needed to adjust each participant's feedback was in agreement with other studies indicating that within-subjects measurements were needed.

Overall Summary and Rationale of Approach

To determine an approach for enhancing self-regulation of responses to stress there were several issues that had to be addressed. This review of literature established several principles for interventions. On a high level it established how stress was defined both in theoretical terms and in relation to measurable physiological mechanisms and outcomes. Then, the negative impact stress had on performance and what could be done to negate the negative impact were surveyed. Self-regulation emerged as an overarching approach to mitigating stress impact. Breathing at the individual's resonance rate appears to influence HRV and the baroreflex and emerged as a promising area to investigate further. The first aim for the literature review was to verify that HRV was associated with reductions in anxiety and stress. Studies were cited using stressed athletes (Dziembowskal, et al., 2016), mangers (Munafo, et al., 2016), students (Meier & Welch, 2016) and musicians (Wells, et al., 2012) that all found that higher HRV induced by resonance breathing protocols was associated with lower stress and anxiety. Breathing interventions were more effective than other strategies such as walking or journaling. In addition, a meta-analysis (Goessl, et al., 2017) confirmed these results.

The second aim of the review was to confirm that differences in HRV (high vs low) were associated with performance. A series of studies looked at cognitive performance effects and concluded that indeed higher HRV was associated with better performance on tasks associated with executive control. Unlike the studies reviewed in the previous section they used pre-existing levels of HRV with a median split to determine high vs. low levels was especially interesting due to its more ecologically valid approach to police work, and unwarranted aggression (Hansen, et al., 2004; Haller, et al., 2014; Hansen, et al., 2009; Johnsen, et al., 2003; Kaufmann, et al., 2011). Since performance was predicted by high verses low HRV and separately resonance breathing had the ability to adjust HRV and reduce stress the next question was whether direct manipulation of breath could adjust HRV and thus performance. Cognitive performance was addressed first in the review. Not all studies confirmed that breath interventions impacted performance. Those with single sessions for the intervention did not produce reliable performance results. Those comprising more than one session seemed to show increasing HRV being associated with larger improvements to performance (Prinsloo, et al., 2011; Sutarto, et al., 2013).

The next issue reviewed was the use of resonance breath to adjust HRV and thus physical performance. A case study involving an Olympic trap shooter was included due to shooting's applicability to both police and military (Gross, et al., 2016). This case study was a success helping the shooter self-regulate stress, especially after a missed shot. This allowed her to qualify for the next round of competition. Two studies with dancers were reviewed that both showed improvements in performance following ten sessions of breathing biofeedback. Lastly runners were given a ten-week protocol of resonance breathing biofeedback that resulted in larger performance improvements compared to controls. This section covered a range of physical movement activities. The results of the studies have led to the conclusion that using resonance breathing to adjust HRV is a technique that can reduce stress and enhance performance.

Statement of the Problem:

In general, the literature reviewed has shown that HRV has a positive relationship with both cognitive and physical performance. It is thought that HRV reflects the body's ability to regulate stress, leading to performance enhancement with higher HRV. The literature also showed that various biofeedback displays, and differing numbers of training sessions used to provide resonant breathing training were successful in changing HRV scores. The changes in HRV were associated with beneficial changes to stress and performance over a variety of domains. Impacts became greater as more practice and training sessions were added. During breath intervention total HRV tends to increase as does RSA and shifts to the LF range that the participants are breathing in. After interventions there is a shift to the HF ranges where stress is thought to be better controlled by the PNS.

In the situations that police and military encounter, it may be impossible to apply some of the self-regulation techniques mentioned earlier while at the same time carrying out duties. Both groups make rapid decisions under life threatening conditions. Therefore, stress management strategies that would allow them to monitor and control stress in the operational context would be especially beneficial. A strategy that would be useful to these groups would need to be implemented before the stressful situation took place. The use of a breathing strategy meets this requirement. Police and military often do not have time during a stressful event to think about their stress and change it on the spot. However, they remain vulnerable to the various operational stressors previously described (Napier & Johnston, 2014; Patterson, et al., 2014). Using breath to adjust HRV is a unique solution in that it allows the person to control his or her physiological mechanisms that help regulate stress well before the physiological and subjective response begins. The individual need only acknowledge that they will be under stress and take steps to regularly practice breathing before the stressful encounter begins to receive the benefits. There is a gap in the literature in that police have not had a long-term breathing protocol applied to them in order to try to adjust HRV and thus regulate stress and performance.

A breathing protocol based on Lehrer et al. (2000) has been developed that shows promise for helping self-regulation processes in the critical situations encountered by police officers. This protocol has been shown in the past to positively impact physiological systems known to regulate stress responses. Practicing this breathing pattern is thought to train the body to regulate stress more effectively and to return to non-stressed states more quickly (Lehrer & Gevirtz, 2014).

Testing this protocol on police cadets accomplished several goals. It allowed police cadets to learn to monitor themselves and recognize stress states by providing biofeedback in practice sessions. It determined if the benefits of adjusting HRV through breath transferred out of a lab setting to a more ecologically valid setting. It can also be used in the future to fill in gaps in models.

The project tested the impact of a breathing protocol on resting HRV in a sample of police cadets. Previous research suggested that the protocol would increase resting HRV, reduce subjective stress, and improve performance, relative to a control group. Performance was assessed on a series of cognitive and physical tests included in cadets' standard training curriculum and a simulated operational scenario given at the end of training.

A means for testing the effectiveness for the protocol is to follow police cadets as they follow their training course. Training may be stressful due to long hours and a fast pace which are both physically and cognitively demanding. There are daily physical fitness classes as well as defensive tactics. Tests can cover a host of legal processes that officers must understand. The fast pace means there is very little time to study and prepare before the cadet is tested. In addition, there is high pressure to perform well in order to pass a final exam. Dropout rates can be quite high due to stress.

Training on the breath protocol had the advantage that it could be integrated with course activities, such as breathing right before an exam, and it afforded the opportunity for participants to practice in a classroom setting complemented by practice at home. It was also possible to develop a control condition, the lack of which was often a weakness in other studies. An additional benefit to having a control condition was that cardiovascular fluctuations were observed in the absence of breathing protocol such as in the case of exercise. This allowed those fluctuations due to exercise to be accounted for.

The police cadet training context supported the measurement of the dependent variables shown in the literature review to be sensitive to breathing interventions. We used wearable sensors incorporated into a "life vest" to assess physiological indicators of stress in the training environments. The primary dependent variable, HRV, was measured on several occasions in the training course. This measure was complemented by additional physiological stress measures. Subjective stress was also assessed at regular intervals through the course.

Performance was another type of dependent variable. Two kinds of performance were assessed in the training context. The first performance dependent variable was student grades on required weekly tests. The second was the student's performance on a simulation in an operational scenario. This simulation was typical of police operations and involves the cadet assisting a team of police in the capture of four suspects. There were multiple decision points and, in addition, places where weapons needed to be deployed. It represented the culmination of techniques and procedures learned in their class.

A subsidiary aim was to investigate whether individual differences in resilience traits predicted stress outcomes and performance. Generally, it was expected that individuals high in qualities such as hardiness and grit were more resistant to stress. It was unknown whether resilient individuals benefit more or less than those vulnerable to stress from breathing interventions, but accommodations for individual differences may enhance the benefits of stress mitigation.

Hypotheses are as follows:

1. It was hypothesized that the experimental group would have greater improvements in their HRV (i.e., increased HRV) than the control group.
2. It was hypothesized that the experimental group would show lower anxiety and subjective stress relative to the control group as training progressed.
3. It was hypothesized that the experimental group would show increasingly better performance on the various tests relative to the control group as training progresses.
4. It was hypothesized that the experimental group would show a reduced stress response and better performance in the scenario than the control.
5. It was hypothesized that those participants with resilient personality traits (high in grit and hardiness and low in anxiety) would have higher HRV resting baselines and will show better performance.

CHAPTER THREE: METHODS

Participants

The goal was to obtain sixty participants, 30 for the experimental group and 30 for the control group for this study. Unfortunately, 60 participants were not available and Covid-19 restrictions increased further losses. There were 13 experimental and 9 control participants. Participants were police cadets attending Valencia College, School of Public Safety. Entrance to the cadet program required prospective cadets to pass mental health screenings and physical screenings administered by Valencia College. Scores were not shared with or used by the researcher. The use of the screening measures meant that the researcher did not need to use additional tests to screen out participants. Mental health screenings included:

1. Supplemental Psychological History Questionnaire- "Job suitability assessment after a conditional offer of employment" (Law Enforcement Psychological Service Inc., 2006).
2. Interview / Mental Status Exam.
3. Psychological History Questionnaire – "Self-report questionnaire that collects behavioral and psychological history information that is pertinent to the evaluation of applicants for public safety positions. This information is used by the examining psychologist to determine the extent to which the findings from psychological testing are corroborated by an applicant's actual behavioral history" (JRA Inc., n.d.).
4. Personality Assessment Inventory- "A self-report questionnaire designed to evaluate personality and psychopathology. It consists of 344 items that are answered on a four-alternative scale, with the response options False, Slightly True, Mainly True, and Very True" (Morey, n.d.).

5. California Psychological Inventory- “A self-report questionnaire designed to measure normal-range human behavior. The long-form CPI - 434 consists of 434 true/false items representing concepts such as Tolerance, Responsibility, Integrity, Empathy, and Self-Control-that are commonly used to describe and understand human behavior” (Gough, n.d.).
6. Wonderlic Personnel Test (Form IV) Evaluates high school level language and math skills (Wonderlic & Associates, 1961).
7. NAB Digits Forward / Digits Backward (Form 1)- “Evaluates auditory attentional capacity and working memory for orally presented information” (Stern & White, 2009).

The physical screenings included requirements that participants were able to run a mile and a half in 18 minutes, take part in daily physical fitness exercises, and defensive tactics classes. Therefore, participants who might have otherwise been excluded from this study, due to physical or mental health issues, had already been removed from the cadet population.

Instrumentation and Facilities

VirTra

VirTra is a simulator that wraps around the participant 300 degrees (see Figure 2). The participant stood on a stage in the middle of the screens where he or she interacted with the scenario. It was housed at Valencia College.

Figure 2: VirTra Simulator
Source: www.virtra.com

Both groups took part in a final training simulation in the VirTra simulator at the end of the course. This session was used to assess performance on cognitive and physical skills appropriate to law enforcement by taking part in a typical police scenario where the participant is to assist other officers in locating and capturing four suspects. There was a continuous story line that is broken into three smaller scenario components. The smaller scenario components marked natural scene changes or natural divisions in the overarching story line.

Scenario 1

The participant saw three officers on a single screen. They were standing outside a residence. The participant was told to go help them. The participant heard directions being given to the contact team. The participant was told that he/she would be the less lethal option and enter with two of the officers. The dispatch indicated that suspect was under a brown tarp in the backyard.

The team proceeded to backyard. The simulation went from a single screen to a full screen as they entered the backyard. Suspect emerged from brown tarp and was not cooperating and made furtive movements towards gun at waistband. The participant may have decided to use a taser on the fugitive. After this interaction the simulated officers moved to arrest the suspect.

Scenario 2

The participant still needed to find three suspects. The participant met a simulated officer in an alley and took direction from him. The participant should have provided cover for him. They proceeded to where the next three suspects were hiding. Updates to the situation were provided by simulated helicopters in the area. The participant began walking through the alley way following directions of the other officer. They were joined by a simulated K9 team. The participant should have bene lethal cover to K9 unit. As they proceeded up the road the team approached a perimeter unit. The police car with the officer was facing to the right. There was another officer across the street also facing right. The team turned to the right when they get to the corner. The dog indicated that the suspects were in carport in front of house. The participants should have positioned themselves outside along with the simulated team. The contact officer yelled commands at the suspects. Three suspects appeared from behind vehicle. Two suspects ran to back yard. One ducked back behind vehicle. The dog was released. The suspect came out and was attacked by dog. The suspect had a gun and shot at the participant. Scenario ended with 2 officers arresting suspect.

Scenario 3

This started in the carport as the suspect was being arrested. The participant should have prepared to head to the backyard in pursuit of the final two suspects. The participants should have followed the other officer to back yard. One suspect appeared and placed a gun to his own head. The participant should have positioned himself or herself correctly and tried to de-escalate the situation. The participant may have chosen to shoot the suspect or do nothing. Afterwards the final suspect appeared in the ally to the right. This ended the scenario.

Coherence Pro

Coherence Pro pacer is an application available for IOS (Apple) or Android that allows the participants to practice breathing at the correct pace for resonance. Coherence Pro provided a pacer that can be set to various respiratory rates. The pacer was a display that indicated when the participant should be inhaling and exhaling to attain a given rate. Coherence Pro also provided a bio feedback display that indicated how close the person was to their resonance rate by assessing HRV as the person is practicing breathing. Participants adjusted their breathing to produce the best resonance rate/ highest HRV. The pacer also kept a record of practice and scores were given to the researcher once a week. More information can be found at: http://www.heartrateplus.com

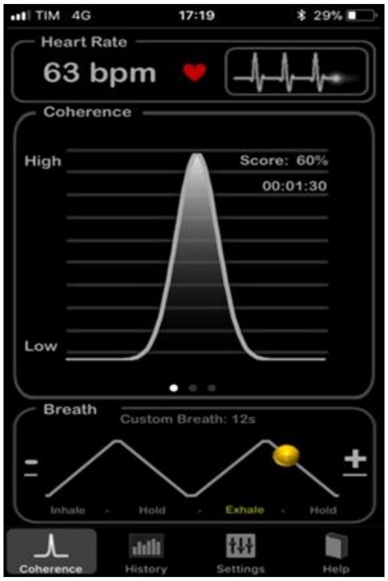

Figure 3: Coherence Pro Display

Equivital EQO2 Life Monitor

The Equivital EQ02 LifeMonitor is a cloth sensor belt (Figure 4) with built in physiological sensors (Patton, 2014; Patton & Gamble, 2016; Patton, Loukota, & Avery, 2013). It can be used in lab or field studies because it is low in weight, and can be cleaned in a standard washing machine. It has been used in previous Army Research Lab (ARL) studies (Patton, 2014; Patton & Gamble, 2016; Patton, Loukota, & Avery, 2013). The physiological sensors are built into the strap that goes around the participant's chest. The sensors can collect raw electrocardiogram (ECG), and respiration rate. Heart rate variability (time and frequency domain) can be calculated from the raw ECG data. These two measures were used to derive other heart rate variability measures. The Equivital data box sits in a pocket built into the LifeMonitor vests and plugs directly into it. It is pictured in figure 4. After each use, the Equivital data box (see figure 5) was wiped clean with an isopropyl alcohol swab as an antiseptic cleanser.

Figure 4: Life-monitor vest
Source: www.mindtecstore.com/Hidalgo-Equivital-EQ02-SEM_1

Figure 5: Equivital data box
Source: www.mindtecstore.com/Hidalgo-Equivital-EQ02-SEM_1

Materials/Tests

Consent forms were IRB approved and included in Appendix J, K, and L. A demographics survey included, age, gender, work background (such as former military or police experience, managerial experience) and meditation experience. It was used to keep the control and experimental group as balanced as possible. It is included in Appendix A.

Anxious Thought Inventory (Wells, 1994)

This is a 22-item self-report questionnaire that utilizes a 4-point scales, including subscales for social, health, and meta worry. An example of a social worry question is "I worry about my appearance" (Wells, 1994). The Cronbach's alpha for social worry reported by Wells (1994) was .84. This study found a Cronbach's alpha for social worry of .904. An example of a health worry question is "I have thoughts about being seriously ill" (Wells,1994). The Cronbach's alpha for health is .81. This study found a Cronbach's alpha for health of .801. An example of a meta-worry question is "When looking to my future I give more thought to the negative things than the positive things that might happen to me" (Wells, 1994). The Cronbach's alpha for meta-worry is .75. This study found a Cronbach's alpha of .784. Wells (1994) reviewed multiple studies showing that the Anxious Thought Inventory scales are appropriate to a range of factors. The subscales were correlated with both self-consciousness and Eysenck's Personality Inventory. Trait anxiety, private self-consciousness, public self-consciousness, social anxiety and neuroticism all showed positive correlations with subscales. Extraversion showed a negative correlation with the subscales. The Anxious Thought Inventory is included in Appendix B.

Hardiness Scale (Bartone, Ursano, Wright, & Ingraham, 1989)

This measure of resilience has 30 items, answered on 4-point response scales. The subscales are commitment, challenge, and control. An example of a commitment question is "Most of my life gets spent doing things that are worthwhile". Commitment questions have Cronbach's alpha of .82 (Bartone et al., 1989). This study found Cronbach's alpha of .648 for commitment. An example of control question is "Planning ahead can help avoid most future problems" (Bartone, et al., 1989). Control questions have a Cronbach's alpha of .66. This study found Cronbach's alpha to be .273 for control. An example of a challenge question is "I do not like to make changes in my everyday schedule". Challenge questions have a Cronbach's alpha of .62. This study found the Cronbach's alpha of .507. Bartone et al., (1989) conducted a study that assessed validity of the hardiness scale by looking at how hardiness regulated the impact of disasters on those in support roles. Measures taken six months after exposure indicated correlations between delayed negative effect and hardiness as well as a protective function. The Hardiness scale is included in Appendix D.

Short Grit Scale (Duckworth & Quinn, 2009)

This questionnaire includes 12 items, answered on 5-point response scales, which assess capacity to sustain effort and interest in demanding activities. Specifically, it looks at perseverance as a trait and commitment to completing goals that will be of long duration. An example of a question is "I have overcome setbacks to conquer an important challenge" (Duckworth & Quinn, 2009). Cronbach's alpha reported by Duckworth and Quinn (2009) was .73. This study found a Cronbach's alpha of .714. Duckworth and Quin (2009) reviewed multiple studies showing that the Grit-S scales are appropriate to predictive validity, consensual validity, and test- retest stability. Measure included comparisons to other measures of grit, as well as performance measures of various groups. The survey is included in Appendix E.

The State Trait Personality Index (STPI) (Spielberger & Reheiser, 2004)

This survey was given each week either during the formal breathing sessions for the experimental group or doing physiological measures for the control group. Only the questions used from the State Trait Personality Index (STPI) that measure state anxiety were used. There are 10 questions. The response options range from 1-4 with 1 being "not at all" and 4 being "very much so". An example of a question is "I feel calm" (Spielberger & Reheiser, 2004). The alpha coefficient was .90. This study found a Cronbach's alpha of .875. Spielberger and Reheiser (2004) validated the scale by looking at differences between state scores under stressful and non-stressful conditions. Further validation compared state to trait scores under stressed and non-stressed conditions. The test authors reviewed multiple studies that showed the scales were appropriate to an appropriate range of factors. The survey is included in Appendix F.

Short Dundee Stress State Questionnaire (Matthews, Joyner, Gilliland, Campbell, Huggins, Falconer, 1999)

The Short Dundee Stress State Questionnaire was given pre and post final scenario (Matthews, Joyner, Gilliland, Campbell, Huggins, Falconer, 1999). The shortened version of the DSSQ scale has 21 questions graded on a 4-point scale that measures task engagement, distress, and worry. The DSSQ is used to assess subjective stress levels following each task type. The DSSQ requires a pre-test to be completed before beginning the experiment and a posttest afterwards. Due to time constraints, the short form was used, which produced measures of Task Engagement, Distress, and Worry. Matthews et al. (1999) reviewed multiple studies showing that the DSSQ scales are appropriate to a range of factors. This study found Cronbach's alpha DSSQ pre worry of .717, distress of .816, and task engagement of .661. This study also found Cronbach's alpha DSSQ post worry of .534, post distress of .876, and post task engagement of .667. The DSSQ was validated using various task stress manipulations. These manipulations produced expected changes in task engagement distress and worry scores. For example, vigilance is a boring and fatiguing task. After vigilance tasks the DSSQ task engagement score went down. It is included in Appendix G.

NASA Task Load Index (Hart & Staveland, 1998)

NASA Task Load Index was given after the final scenario. It measures 6 sources of workload (mental demand, physical demand, temporal demand, effort, frustration, performance) utilizing a 0-100 rating scale. Overall workload is measured by calculating the average of the ratings. Hart and Staveland (1998) showed workload ratings were appropriately sensitive to a variety of task manipulations such as "simple cognitive and manual control tasks, complex laboratory and supervisory control tasks, and aircraft simulation". The studies found that "task, behavior, and subject-related correlates of subjective workload experiences varied as a function of difficulty manipulations within experiments, different sources of workload between experiments, and individual differences in workload definition." The survey is included in Appendix C.

Exams were given as part of the course almost every week during the course. They were not for public release; however, grades on them were analyzed.

Rubric for Simulated Operational Performance.

A final simulation in the VirTra at the end of the course was used to assess cadet performance on cognitive and physical skills appropriate to law enforcement. The cadets took part in a typical police scenario where the participant assisted other officers in locating and capturing 4 suspects. The scenario included, stressors such information ambiguity/reliability and time pressure, task interdependence among unknown team members, equipment failure, and multi-tasking. This scenario is used in cadet training and provided by the school. Training officers created a rubric of desired behaviors and decisions appropriate to the scenario. Although a continuous variable was desired the instructors found that too difficult to grade while in simulation. Instead they chose a simple present or not present grading scheme. Training officers graded performance of the participants based on a rubric and provide them with feedback. The cadets made rubrics available to the researcher.

The rubric for grading the cadet's responses to events of the story line in the VirTra simulation was broken down into three consecutive scenarios. Under each of the scenarios was a high-level description of what happened in the scenario. Next, behaviors were listed that reflected different types of decisions that the cadets should have made. The instructors indicated if the behavior took place or not. During the debrief there were additional questions to ask that indicated the cadet's situational awareness. It is included in Appendix H.

Westside Test Anxiety Scale (Driscoll, 2007)

The Westside Test Anxiety Scale (Driscoll, 2007) was given in the first session. It "is a brief, ten item, instrument designed to identify students with anxiety impairments who could benefit from an anxiety-reduction intervention" (Driscoll, 2007). Responses are scaled from 1 to 5 with 1 being "not at all or never true". Five represents "extremely or always true". An example of a question is "The closer I am to a major exam, the harder it is for me to concentrate on the material" (Driscoll, 2007). It has a .44 coefficient of validity in predicting change in test scores following an anxiety reducing intervention. The construct reliability is .88 (Talwar, Matheiken, Lee Ai Cheng, & Sabil, 2019). This study found a Cronbach's alpha of .862. It should only take five minutes to take. Driscoll (2007) conducted a review to validate that the Westside Test Anxiety scale was appropriate to a range of factors. Control and intervention groups were identified. Both groups had a pretest. The intervention group had anxiety reducing training. Then both groups had a post test. "The correlations between the anxiety reduction as measured by the scale and improvements in test performance were used as the validation criteria" (Driscoll 2007). The scale is in Appendix I.

Procedures

Potential participants were given an introductory presentation on stress in police officers during the first 3-4 weeks of class that explained the background of the study. Following the presentation, they were given an opportunity to volunteer. The presentation took place in the classrooms at Valencia College School of Public Safety.

The presentation explained how stress impacted both cognitive and physical performance. The physiological stress response and control of stress was explained. The presentation also covered methods for mitigating stress. Possible benefits of stress mitigation in relation to stress response and enhancement of physical and cognitive performance in the police context were discussed. The presentation concluded with an account of the study and the activities to be performed by participants, including time commitments.

Two groups of cadets participated, a control group and an experimental group. The groups were told that the researcher was trying to evaluate different methods of stress mitigation for the police, using techniques developed for other populations such as the military. Only the experimental group was trained in the breathing intervention. The control group had discussions on stress mitigating techniques that did not overlap in the content. They discussed looking for good in their lives, counteracting confirmation bias, core values and goal setting.

Before Training Session

Participants signed the informed consent and were given their unique identifier. After signing the consent form the participants completed initial surveys. This included the Consent form, Demographics questionnaire, Anxious Thought Inventory (Wells, 1994), Hardiness scale (Bartone, et al., 1989), Short Grit Scale (Duckworth & Quinn, 2009), STPI (Spielberger & Reheiser, 2004) and Test Anxiety Scale (Driscoll, 2007).

The experimental participants downloaded the Coherence Pro pacer application to assist the participants in learning the breathing technique. The researcher purchased the application and helped the cadets download it.

The experimental and control participants were fitted with an Equivital Eqo2 Life Monitor to assess electrocardiogram (ECG). A locker room was provided to change in privacy without a researcher present. A researcher ensured proper fit and that the data box was in the correct location. Female participants were always be checked by a female researcher; due to time constraints due male participants were checked by either a gender researcher unless they had a preference. Each data collection box was labeled with a number. The researcher recorded the time the box was turned on. Once the shirt was on the participant's body and the researcher was satisfied with the fit and data box location, the researcher recorded the time, shirt size, box number, participant's ID number, and date.

Once the equipment was fitted the participants provided a baseline of physiological measures. The participants took a seat in a room. The lights were dimmed, and the start time was recorded.

Participants relaxed for 10 minutes. Baseline measures of HRV, respiration rate, and heart rate were collected during the 10 minutes interval. The control group was free to leave after this assessment. The baseline measures were repeated at the end just before the final training simulation for all participants.

Determine Resonance Breath Rate (Experimental Only)

The last thing the experimental participants did was to determine their personal resonance breath rate. Participants continued wearing the Life Monitor. Participants were shown how to pace their breath with the Coherence Pro application. The researcher emphasized longer exhale than inhale breaths. Participants breathed at several different frequencies.

Due to limitations in the Coherence Pro pacer the changes in respiratory rate was measured in seconds per breath rather than breaths per minute. The participants breathed at each frequency for two minutes with a break in between to reset the pacer. The frequencies were: 12 second breaths (5 breaths per minute), 11 seconds per breath (5.45 breaths per minute), 10 second breath rate (6 breaths per minute), 9 second breath rate (6.67 breaths per minute), and 8 second breath rate (7.5 breaths per minute). The coherence scores provided by the Coherence Pro application during each breathing interval were recorded. At each frequency when (if) the display indicated 80% on the Coherence Pro application for the first time the elapsed time since starting that frequency was recorded. The frequency in which the participant achieved 80% coherence in the lowest amount of time became the resonance frequency at which they practiced. Those that did not reach 80 % used their highest score and the researcher tried to work with them more to help them reach that rate. by the participant to practice.

Formal Weekly Sessions

Typically, up to once a week, participants took part in a formal session with the researcher. There were exceptions for holidays and class schedules. During this session they took a Self-Analysis Questionnaire STPI Form Y-1 questionnaire and showed the researcher their exam score for that week. These included pre and post physical test scores as well as class exams that are more cognitive in nature. The pre and post physical test scores could not be used in the end. The tests were taken outside. This meant that the first class had their first run in the summer in high heat and their final run in the winter with lower heat. The second group had their first test in January and their final test at the end of May. This created a huge advantage for the first group.

The experimental group practiced breathing at their resonance rate for 20 minutes. They received feedback based on the researcher's observations of their breathing technique. The participants also provided the record of their practice sessions as recorded by the Coherence Pro application to the researcher. The control group met once a week as well. During this session they took the Self-Analysis Questionnaire STPI Form Y-1 questionnaire. Then the control group met once a week for ten minutes (unless they chose to stay longer) and discussed a coping method to deal with typical daily stressors. They were encouraged to come up with their own examples and apply the method as homework. The following week they discussed whether it worked or not and started discussing a new coping method. This was done in person until the Covid-19 virus forced a shutdown of face to face interactions. At that point the control group met using a telephone on speaker and emailed their STPI results. The experimental group indicated that they would contact the researcher if they had problems and would email their breathing homework and their STPI as well. Formal practice with either group was not held the two weeks they were at the range due to lack of cell signal.

Homework Practice and Recording

Experimental participants were asked to practice breathing for a minimum of 20 minutes a day. Scheduling of practice was flexible. Practice can be broken into four, five-minute segments (for example) or longer segments so long as the minimum total of 20 minutes is reached. This was done to make it more convenient for them to practice as instructors indicated before the study that they were unlikely to practice in 20-minute segments but might if they were broken down. It is not known if breaking it up is the same as a longer session. Home session practice was recorded by the Coherence Pro application. Recorded practice was shown to the researcher once a week and recorded. While this was done to ensure compliance the cadets often did not do the full twenty minutes, and no one was fully in compliance by the end.

Baseline Intervals

Initial baseline data were collected in the beginning as described above. Baseline data were supposed to be collected again for experimental and control participants at a time between 4-6 weeks from initial baseline. However, due to Covid-19 restrictions this could not be completed. Baseline data were collected again on participants at the end of training prior to time in the simulator.

Final Simulation Day

Upon arrival on the day of the simulation participants put on the Life Vest. Baseline physiological measures were taken (as described in previous sections). The Dundee Stress State Questionnaire (DSSQ) short version was taken prior to the scenario and debrief and immediately afterwards. NASA Task Load Index (Hart & Staveland, 1998) was given after the final scenario and debrief. Participants performed in the scenario one at a time.

This scenario was used in cadet training and provided by the school. It was described earlier. Training officers used a rubric to provide feedback on performance of the participants. Participants made rubric with feedback available to researcher. In addition, shot accuracy and response time were collected when it was appropriate for the officer to shoot. Unfortunately, the amount of missing data on the shot accuracy and response time made it impossible to analyze. Feedback was given to participants about their performance during the debrief by the instructors rating them. The participants gave the rubric with the feedback on it to the researcher. The rubric was scored using percent of correct actions or decisions.

ECG Analysis

The interaction between the ANS, heart, and brain is responsible for much of the variability in IBI (Shaffer and Ginsberg, 2017). Studies that evaluate HRV often capitalize on that connection to determine the emotional state of the individual. There are several different ways that HRV is analyzed using ECG data. They are often grouped into time domain and frequency domain measures. VivoNoetics VivoSense software was used to analyze HRV data. This program is based on the recommendations of the European Society of Cardiology and the North American

Society of Pacing Ectrophysiology (Patton & Gamble, 2016). Below some common methods of analyzing HRV data and their suitability for the study are discussed.

Time Domain

Time domain measurements of HRV specify how much total variability there is in the time between heart beats (HRV task force, 1996). They often use various statistical models to describe that variability (Shaffer & Ginsburg, 2017; VivoSense, Inc., 2017). The goals of the study determine which measurement it made sense to use and the measurements cannot be exchanged with each other. Time domain measurements are related to measures in the frequency domain and are generally considered to be measures of autonomic balance.

Standard Deviation of the R-R Interval (SDRR)

The standard deviation of the R-R interval (square root of variance) is a common analysis metric (HRV task force, 1996). It is capable of measuring both long- and short-term changes (Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014). The standard deviation of the R-R series difference can measure all the changes that take place. That means that when the measure is converted to the frequency domain it can reflect all the frequency ranges as long as the recording is long enough. Thus, it is related to the total power in the frequency domain (VivoSense, Inc., 2017). However, it is inappropriate for this proposal because the variance increases as the time of the recording increases. This makes it impossible to compare to other studies if they have different recording times.

Root Mean Square of the Successive Difference (RMSSD)

RMSSD indexes the variability between consecutive IBIs. RMSSD is found by subtracting successive R-R times from each other. These are measured in milliseconds (ms). Each of these numbers are then squared. The sum of all the numbers is calculated. Shorter five minutes recordings are appropriate. This measure is related to the high frequency band and RSA. The PNS (vagal) influence means that it is related to high frequency when changed to that domain (VivoSense, Inc., 2017). This measurement is related to RSA and thought to be controlled by the PNS (vagally) (Shaffer & Ginsberg, 2017; U.S. Department of Homeland Security, Federal Law Enforcement Training Center, 2011). Thus, when breathing at resonance rate (which is at low frequency) the RMSDD is lower. This can be used to analyze data in the study. The baseline periods should reflect higher RMSDD as the study continues on and the resting frequency tends to the controlled more by the PNS.

Frequency Domain

Typically, a fast Fourier transform (FFT) is applied to measures taken in the time domain to convert them to the frequency domain. The frequency domain approximates how the absolute or relative power is allocated across four frequency bands: Ultra-Low Frequency (ULF), Very Low Frequency (VLF), Low Frequency (LF), and High Frequency (HF) (Shaffer and Ginsberg, 2017; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996).

Power is the area under the curve between two points in time. This power spectrum indicates the particular frequencies that make a contribution to the area of interest. These different frequencies represent different physiological processes (Shaffer & Ginsberg, 2017; VivoSense, Inc., 2017) depending on the frequency band, as discussed next.

Ultra-Low Frequency (ULF) (≤0.003 Hz)

Ultra-Low Frequency is measured in 5-minute to 24-hour segments over a minimum of a 24-hour recording (Shaffer & Ginsberg, 2017; VivoSense, Inc., 2017). ULF measures slow acting mechanisms such as circadian rhythms, core body temperature, and metabolism. The role of PNS and SNS is unclear. It is inappropriate for the analyses of acute stress of interest here.

Very Low Frequency (VLF) (0.0033- 0.04 Hz)

There was debate about what processes contributed to VLF (Tarvainen, et al., 2014). The heart produced the VLF rhythm and a well-functioning SNS altered the amplitude and frequency through physical activity and stress response. Beyond sympathetic activity vascular and thermos regulatory function of the heart contribute to frequencies seen here (ChuDuc, et al., 2013). This is inappropriate for the current analysis.

Low Frequency (0.04-0.15 Hz)

This frequency is affected by respiratory rates of around 3 to 9 breaths per minute (Tarvainen, et al., 2014). It is affected by both the PNS and SNS. Typically, an individual’s resonance rate is found within this range. Shifts in power from high frequency to low frequency are common during resonance breathing.

High Frequency (HF) (0.15-0.40 Hz)

Typically, this reflects respiratory rates of around 9 to 24 breaths per minute (Shaffer & Ginsberg, 2017). Measurements in this range indicate PNS activity that corresponded to the HR variations related to respiratory cycle or RSA. This measurement corresponds to RMSSD in the time domain. A high RMSSD number is indicative of high frequency activity. More power in this range in the baselines as time goes on should indicate that the breathing has reduced stress.

Data Analysis

The principal hypotheses were tested using mixed-model Analyses of Variance (ANOVAs), with HRV, subjective stress and performance variables as outcome measures. See Table 2 for more detailed list. Experimental group (breathing or control) was a between-subjects factor with two levels. Three sets of analyses were performed:

Effects of Breathing on Stress Response Changes During the Course

Two-factor (experimental group × course week) mixed-model ANOVAs were conducted to test whether the breathing group shows increasingly smaller-magnitude stress responses than the control group as the course progressed. Course week was a repeated-measures factor indexing repeated testing during the period of the study (see Table 2). Weeks 1 and 10 had HRV stress measures, supporting a 2 × 2 (group × week) ANOVA, for each HRV measure. This answered hypothesis one. Measures in weeks 1-10 were assessed subjective stress in the form of the STPI, supporting a 2 ×10 (group × week) ANOVA. This answered hypothesis 2. Measures in weeks 1-17 assessed the stress response in terms of performance on the class test, supporting a 2 ×17 (group × week) ANOVA. This answered hypothesis 3. We anticipated significant experimental group × course week interactions; i.e., differences in outcome measures between the two groups should have increased in magnitude as the course progression. There may have been a main effect, of course, if, for example, all participants tended to experience less stress over time as they adapted to course demands. Where significant interactions were obtained, follow-up tests were Bonferroni-corrected between-subjects *t*-tests to determine if means on outcome variables differ significantly at specific time-points during the course. Group differences in class test performance were tested with Bonferroni-corrected between-subjects *t*-tests, given that the tests are highly varied in nature.

Table 2: Dependent variables assessed during 10 course weeks

Dependent Variables	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8	Week 9	Week 10
HR	mean HR									mean HR
HRV	RMSSD									RMSSD
Subjective stress	STPI	STPI	STPI	STPI	STPI	STPI	STPI	STPI	STPI	STPI
Performance	Class test	Class test	Class test	Class test	Class test	Class test	Class test	Class test	Class test	Class test

Effects of Breathing on Stress Response Changes During the Simulated Scenario

Analysis answering this question addressed hypothesis 4. Table 2 provides a list of dependent variables for the scenario. For this analysis, a within-subjects “phase” factor was defined, contrasting HRV outcome variable scores during the pre-scenario baseline, during the scenario itself, and post-phase. A two-factor 2 ×3 (experimental group × phase) mixed-model ANOVA was then run for each psychophysiological outcome variable. A comparable 2 × 2 analysis was run for DSSQ scales. Pre-scenario baseline scores were likely to be influenced by anticipatory stress, as participants were aware that the scenario may be demanding. A main effect of experimental group might have then indicated that the breathing group were generally lower in stress than the control group at both phases. A main of effect of phase would have indicated a general increase in stress during the scenario, averaging across both groups. It was also anticipated that there were significant experimental group × phase interactions associated with smaller increases in stress induced by the scenario in the experimental group. Performance and subjective workload measures were assessed on one occasion only, with no baseline data; group differences were tested using Bonferroni-corrected between-subjects *t*-tests.

Table 3: Dependent variables during simulation

Dependent Variables	Week 11 Pre	Week 11 Scenario	Week 11 Post
Performance		Rubric	
Subjective stress	DSSQ pre		DSSQ post
Workload			NASA-TLX
Heart Rate	Mean HR	Mean HR	Mean HR
HRV	RMSSD	RMSSD	RMSSD

Relationships Between Personality Traits for Resilience and Stress Outcomes.

Analysis in this section answered hypothesis 5. Pearson correlations were computed to test the subsidiary hypothesis that personality traits for resilience predict higher resting HRV and superior performance. It was expected that at the beginning of the course resilience traits will predict stress outcomes in all participants, irrespective of experimental group. However, the role of dispositional resilience may change following breathing training. One possibility was that training compensated for the suboptimal coping abilities of low-resilience individuals, so that resilience became less important as training progressed. Tentatively, we anticipated that resilience – stress outcome associations would become weaker over time in the experimental group, but not in the control group. We tested this hypothesis by examining changes in correlation magnitudes across weeks in the two groups separately.

CHAPTER FOUR: RESULTS

Due to Covid-19 restrictions and drop-outs the final number of participants was 22. There were 13 in the experimental group and 9 in the control. There were 14 males and 8 females. However, there may be fewer in any particular test due to missing data on those scores.

There were two sets of ANOVAs analyzed. The first set of three ANOVAs were intended to analyze changes that took place during the course due to practicing the breathing technique. These included changes in HRV baselines, week to week changes in anxiety, and performance on in class tests. The second set of five ANOVAs analyzed changes that took place in the simulator. These included changes in mood from before and after the simulation. This included performance in the simulator, and workload. This was followed by three categories of correlations. The first set of correlations that looked at the relationship of personality traits to week to week changes in anxiety. The next set of correlations looked at the relationship of performance, subjective stress response, and physiological stress responses during the simulation. The third set of correlations looked at the relationship of personality traits taken in the beginning of the study and subjective stress response during the simulation and physiological stress responses.

Breathing Effects on Stress Response

Three analyses were intended to answer whether the breathing group showed increasingly smaller stress responses than the control group as the course progressed. There were three, two-factor (measurement day x experimental group) ANOVAS conducted in order to answer this question. Measurement day was the repeated – measure factors factor indexing repeated testing during the period of study.

The first ANOVA analyzed initial and final HRV RMSSD baselines to see if the breathing protocol improved HRV RMSSD over time. HRV RMSSD baselines were analyzed using a 2 x 2 (measurement day x group) mixed-model ANOVA, with repeated measures on the measurement day. The initial baseline HRV RMSSD was measured in the first week and the final baseline on the final day prior to performance in the simulator. Tests showed no significant main effect for baseline day on the HRV RMSSD, $F\ (1,14) = .440$, $p = .518$, $\eta_p^2 = .030$. There was also no significant interaction between group and HRV RMSSD baseline, $F\ (1,14) = 1.153$, $p = .301$, $\eta_p^2 = .076$. Tests did not show a significant effect of groups on the HRV RMSSD scores, $F\ (1,14) = .845$, $p = .374$, $\eta_p^2 = .057$. The control group's HRV RMSSD at initial baseline was slightly lower ($M = 83.13$) than the experimental group's ($M = 85.99$). At the final baseline the control group's HRV RMSSD mean baseline had dropped to 58.63 while the experimental group's HRV RMSSD mean baseline increased slightly to 91.78. As can be seen in Figure 6; HRV RMSSD Initial and Final Baselines for Control and Experimental Groups, there is a trend showing that the experimental group had an increase in HRV while the control group had a decrease in HRV.

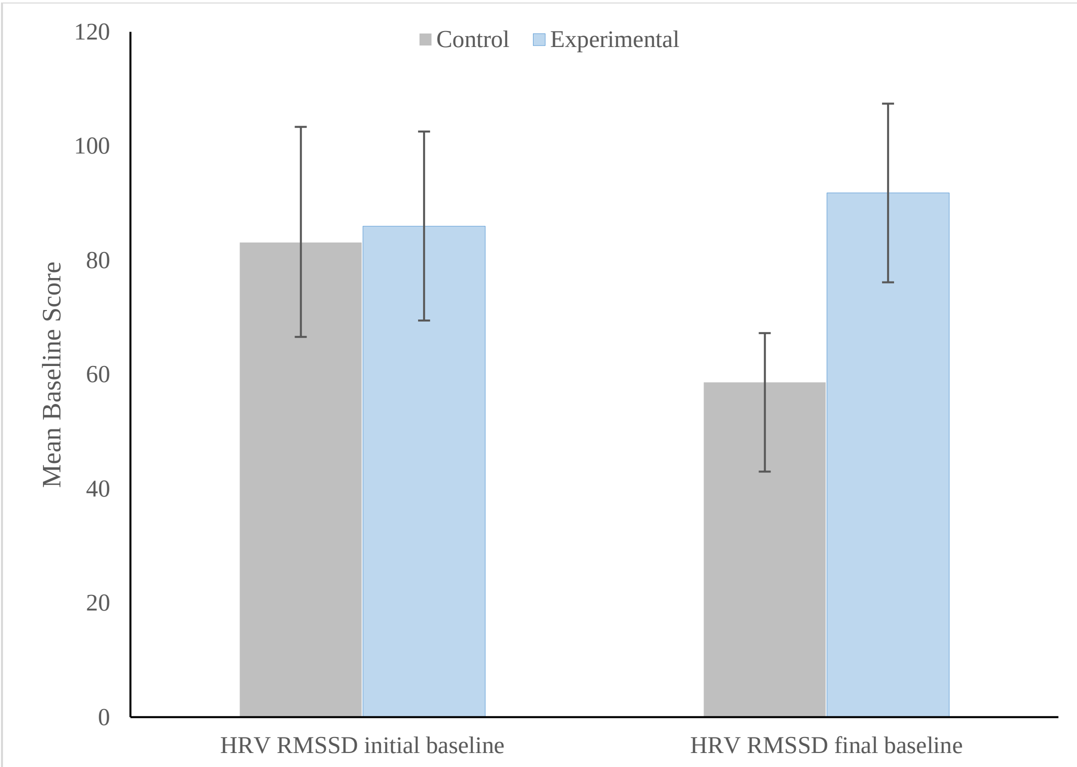

Figure 6: HRV-RMSSD Initial and final baselines for Control and Experimental groups. Error bars in this and subsequent figures represent standard errors.

Throughout the study STPIs were administered weekly to cadets to determine if stress changed on weekly basis as the course progressed. STPI data were analyzed using an 11 x 2 (measurement day x group) mixed -model ANOVA, with repeated measures on measurement day (see Figure 7: STPI Scores in Two Groups Across Eleven Weeks). Mauchly's test of sphericity indicated that there was a significant difference, $p = .002$, so a Greenhouse Geisser correction was applied. The main effect of the measurement day on the STPI scores was nonsignificant, F (5.626, 112.522) = .456, $p = .829$, $\eta_p^2 = .022$. The ANOVA also showed nonsignificant effects of group on STPI scores, F (1,20) = .733, $p = .402$, $\eta_p^2 = .035$ and the measurement day x group interaction, F (5.626, 112.522) = .724, $p = .623$, $\eta_p^2 = .035$.

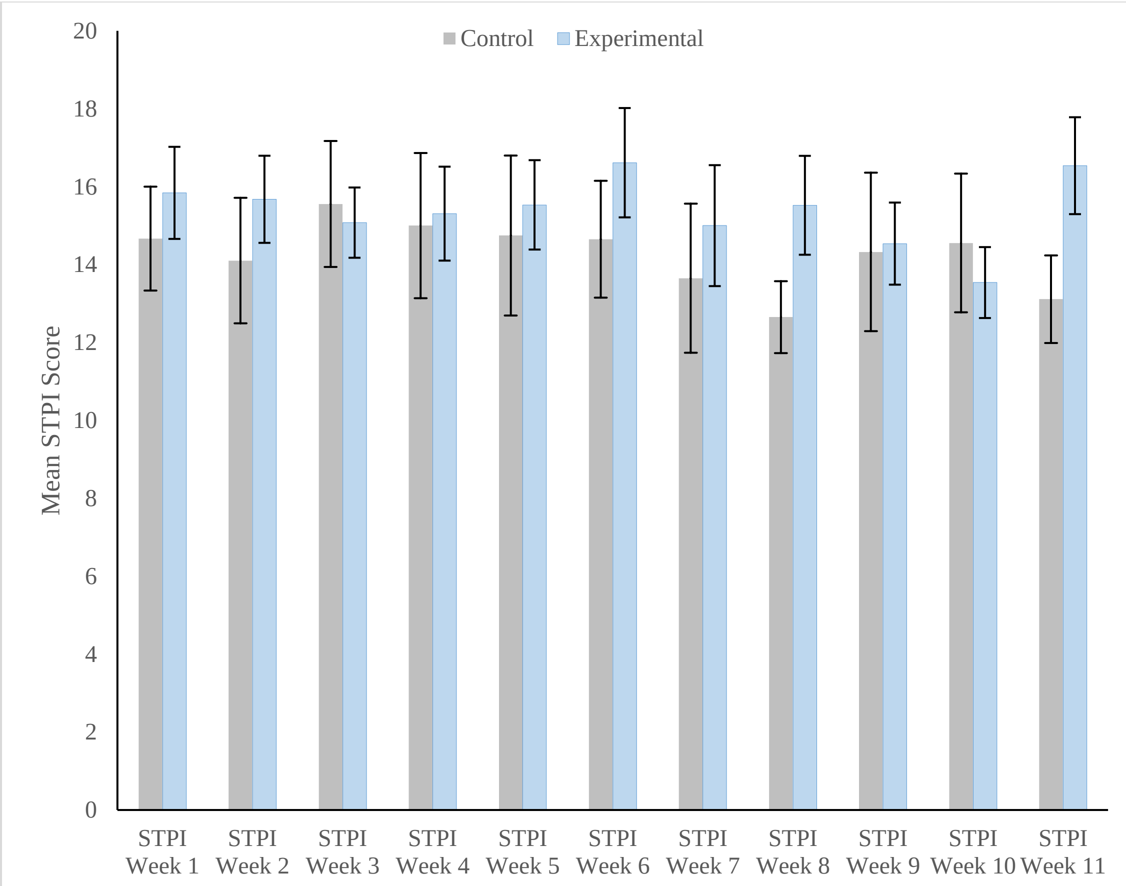

Figure 7: STPI scores in two groups across eleven weeks

Class test performance data were analyzed using a 17 x 2 (test day x group) mixed-model ANOVA, with repeated measures on test day (see Figure 8: Test Scores for Cadet Training for Two Groups). The main effect of test day on the test scores was significant, F (16,320) = 5.033, p = .000, η_p^2 = .201. This finding simply reflects the different content of the test with some being harder than others. The ANOVA also showed nonsignificant effects for both the group, F = (1,20) = 1.959, p = .177, η_p^2 = .089 and the test day x group interaction, F (16, 320) = .834, p = .647, η_p^2 = .020.

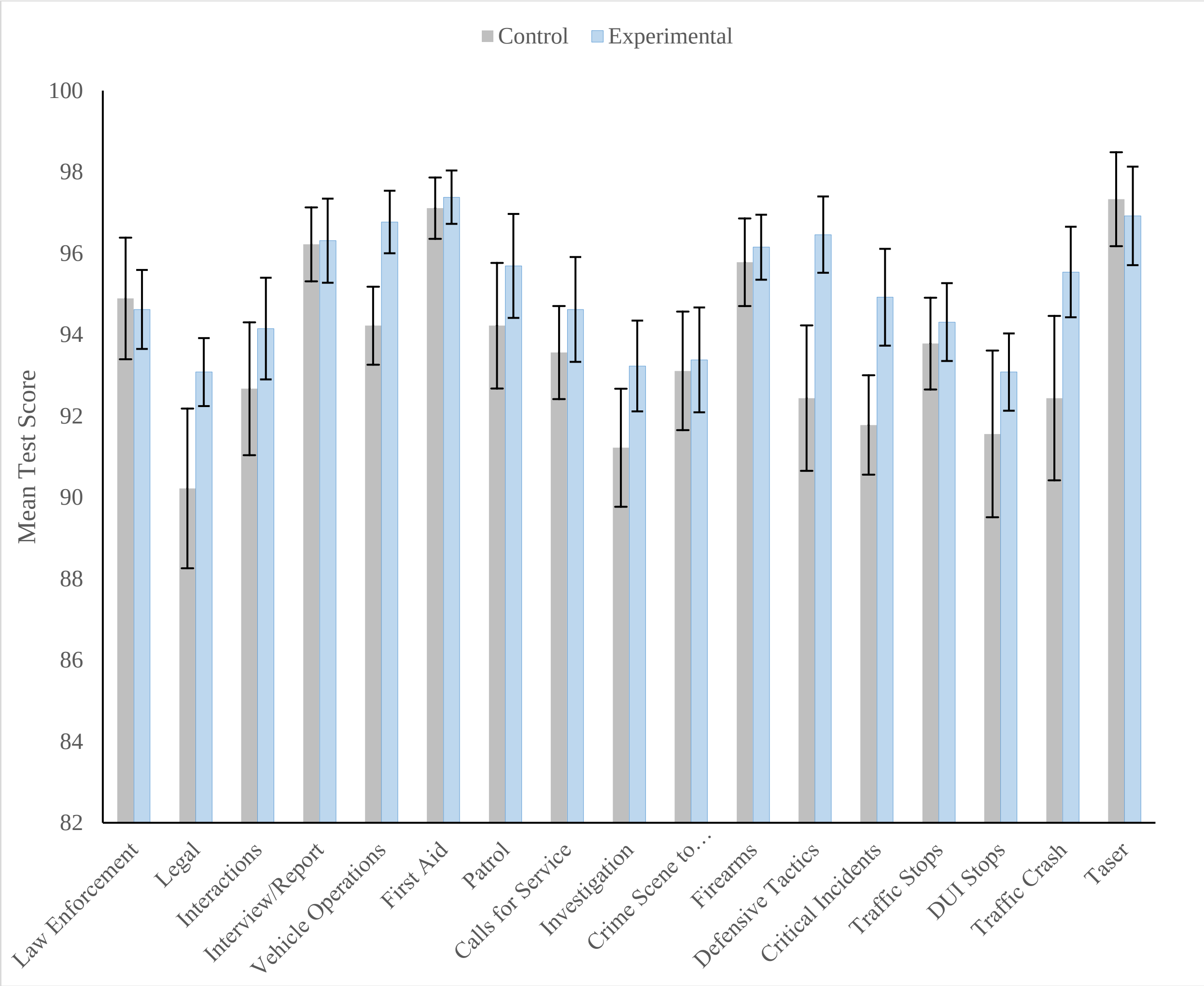

Figure 8: Test scores for cadet training for two groups

Effects of Breathing on Stress Response Changes During the Simulated Scenario

Two sets of ANOVAS were conducted to determine the effects of breathing on stress response changes during the simulated scenario. RMSSD HRV phases (before simulation, during simulation and debrief) were analyzed using a 3 x 2 (phase x group) mixed-model ANOVA, with repeated measures on the phase (see figure 9: HRV RMSSD Simulation Phase for Two Groups). The main effect for phase on RMSSD HRV scores was significant, $F\,(2,26) = 3.986$, $p = .031$,

η_p^2 = .235. HRV tended to decline from the anticipation phase to simulation and then increased in the debrief. There was a nonsignificant effect found for the phase x group interaction, F (2,26) = .218, p = .806, η_p^2 = .016. The ANOVA also found a borderline significant effect for group on the HRV RMSSD scores, F (1,13) = 4.437, p = .055, η_p^2 = .254. The scores for the experimental group were generally higher than those of the control group and never dropped as low as the highest score in control group.

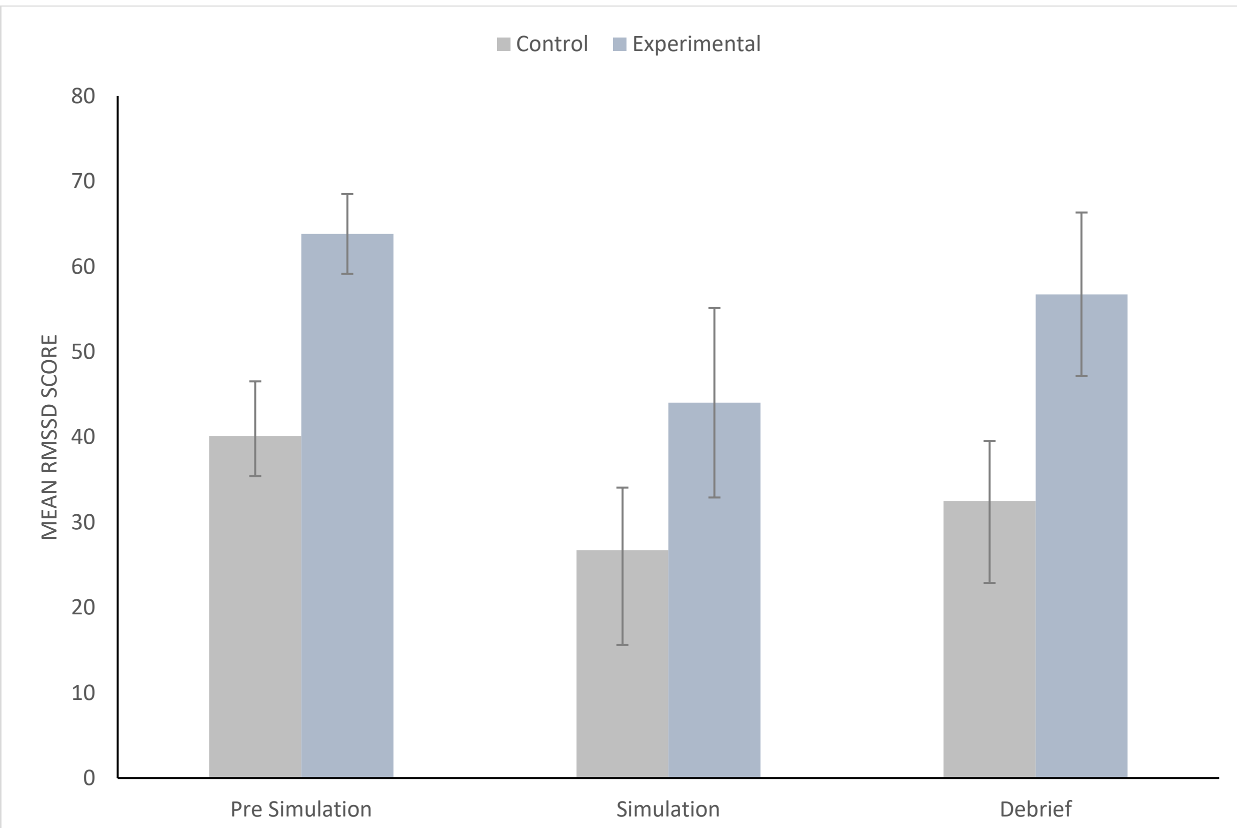

Figure 9: HRV-RMSSD simulation phase for two groups

DSSQ scores were analyzed using a 2 x 2 (phase x group) mixed-model ANOVA with repeated measures on phase. The DSSQ was broken into 3 components, engagement, distress, and worry, which were analyzed separately. The main effect of phase on DSSQ engagement was significant, F (1,20) = 23.124, p = .000, η_p^2 = .536 (see figure 10: DSSQ Pre Task and Post Task Engagement for Two Groups). The ANOVA also showed nonsignificant effects of both group on DSSQ engagement scores, F (1,20) = .309, p = .584, η_p^2 = .015 and the phase x group interaction, F (1,20) = .110, p = .774, η_p^2 = .005. The second component analyzed was distress (see figure 11: DSSQ Pre Task and Post Task Distress for Two Groups). The main effect of phase on DSSQ distress scores was significant, F (1,20) = 14.054, p = .001, η_p^2 = .413. The ANOVA also found a nonsignificant effect for group on DSSQ distress scores, F (1,20) = 1.608, p = .219, η_p^2 = .074. There was a nonsignificant phase x group interaction, F (1,20) = .272, p = .608, η_p^2 = .013. The third component analyzed was worry (see figure 12: DSSQ Pre Task and Post Task Worry for Two Groups). The ANOVA found a nonsignificant main effect of phase on worry scores, F (1,20) = 1.042, p = .320, η_p^2 = .050. The ANOVA showed nonsignificant effects for both the group on DSSQ worry scores, F (1,20) = .370, p = .550, η_p^2 = .018, and the phase x group interaction, F (1,20) = .005, p = .946, η_p^2 = .000. Both groups increased engagement and distress from pre task to post task indicating that the impact of the scenario was to increase engagement and distress but contrary to expectation there was no effect of worry.

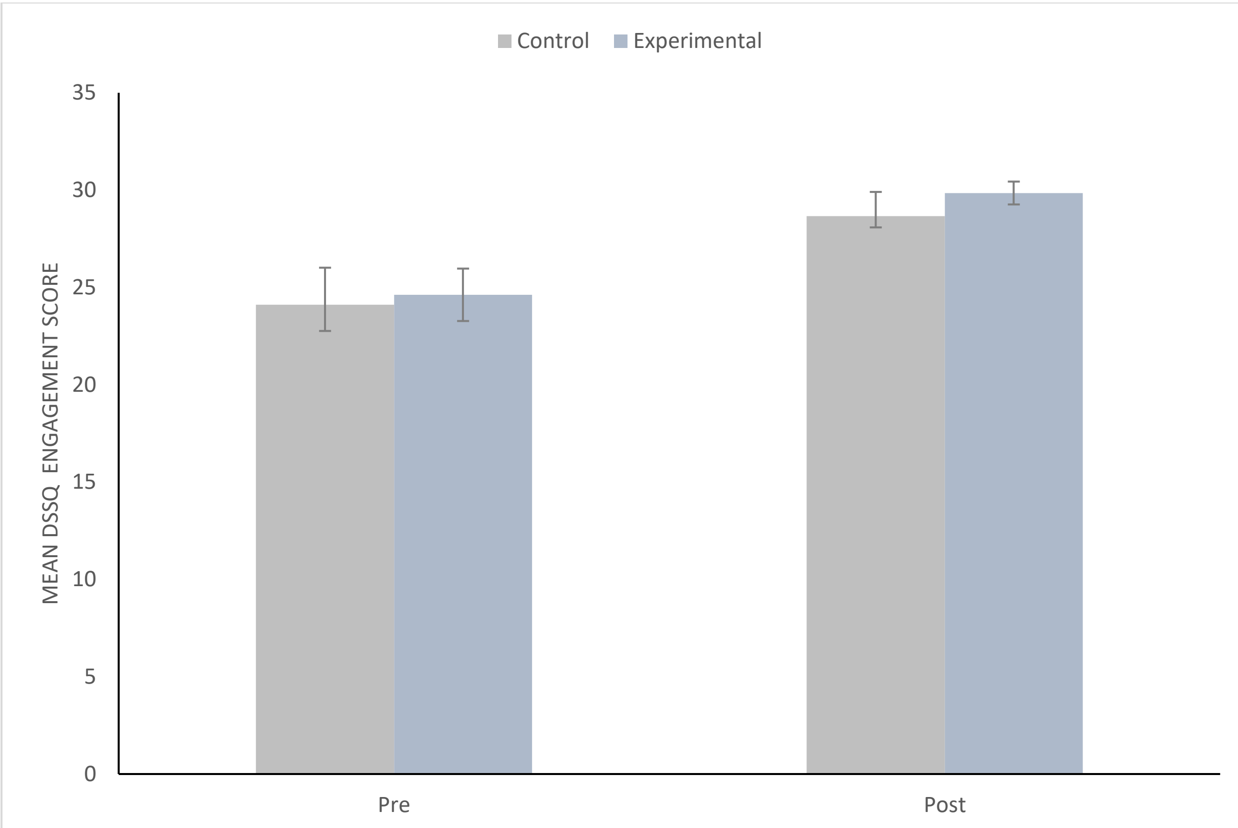

Figure 10: DSSQ pre-task and post task engagement for two groups

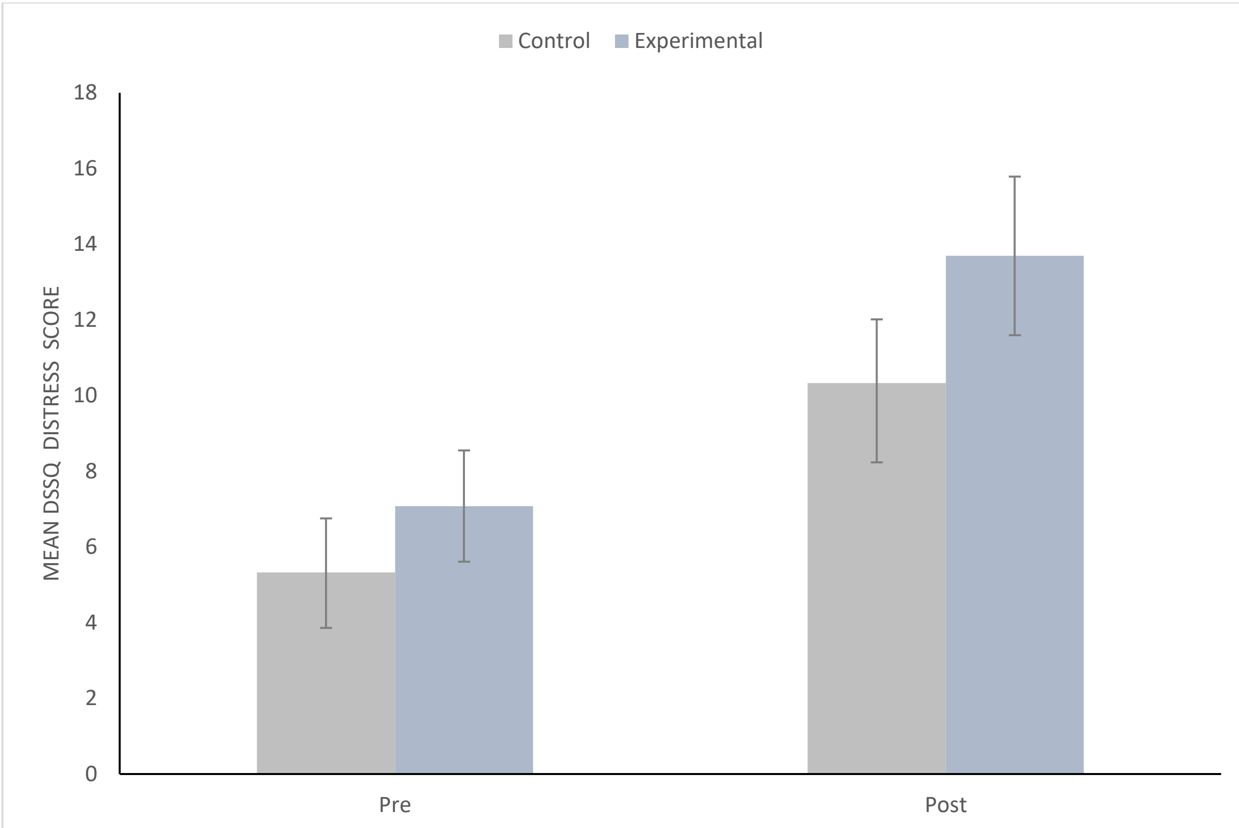

Figure 11: DSSQ pre-task and post-task distress for two groups

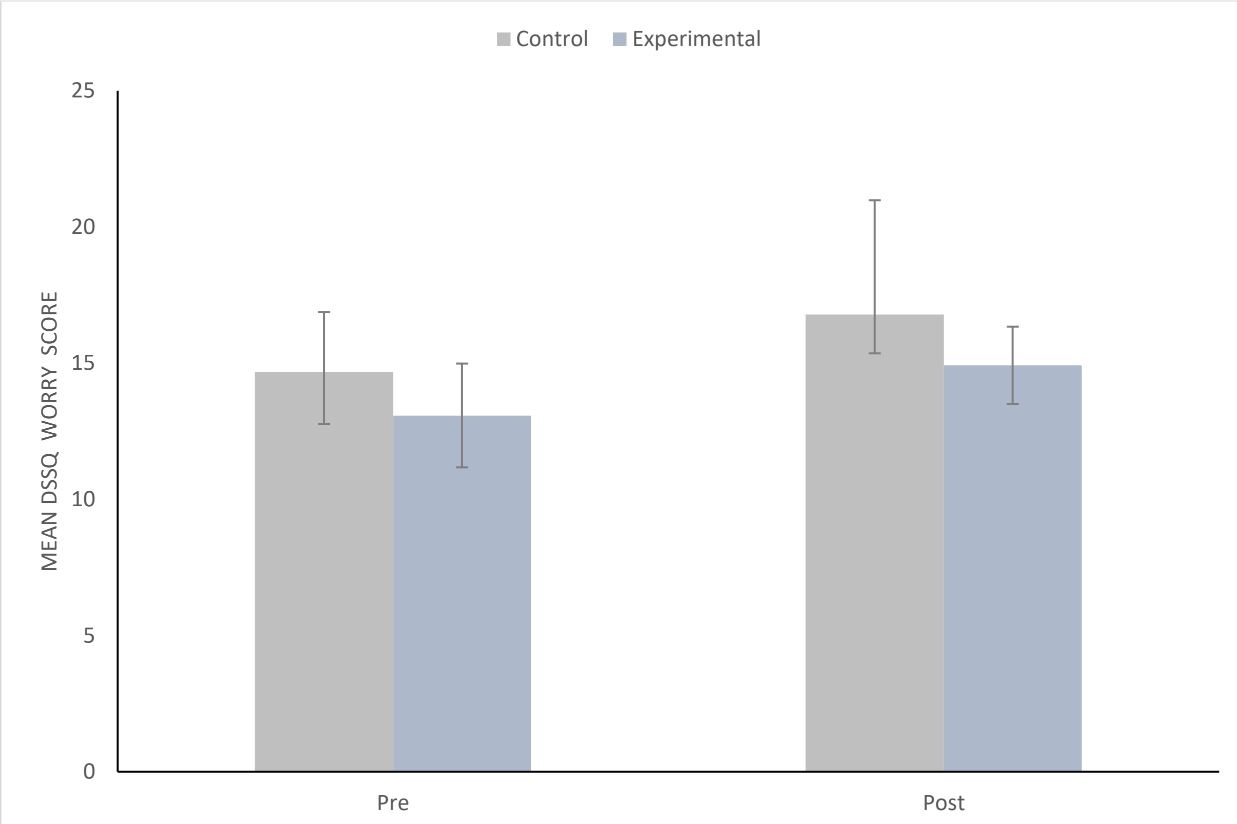

Figure 12: DSSQ pre-task and post-task worry for two groups

Simulator performance

A t test did not indicate a significant difference between the groups on performance in the simulator as indicated by the rubric, *t* (20) = 1.280, *p* = .215 (see figure 13: Performance in the Simulator for Two Groups). The experimental group had a higher performance score than the control group.

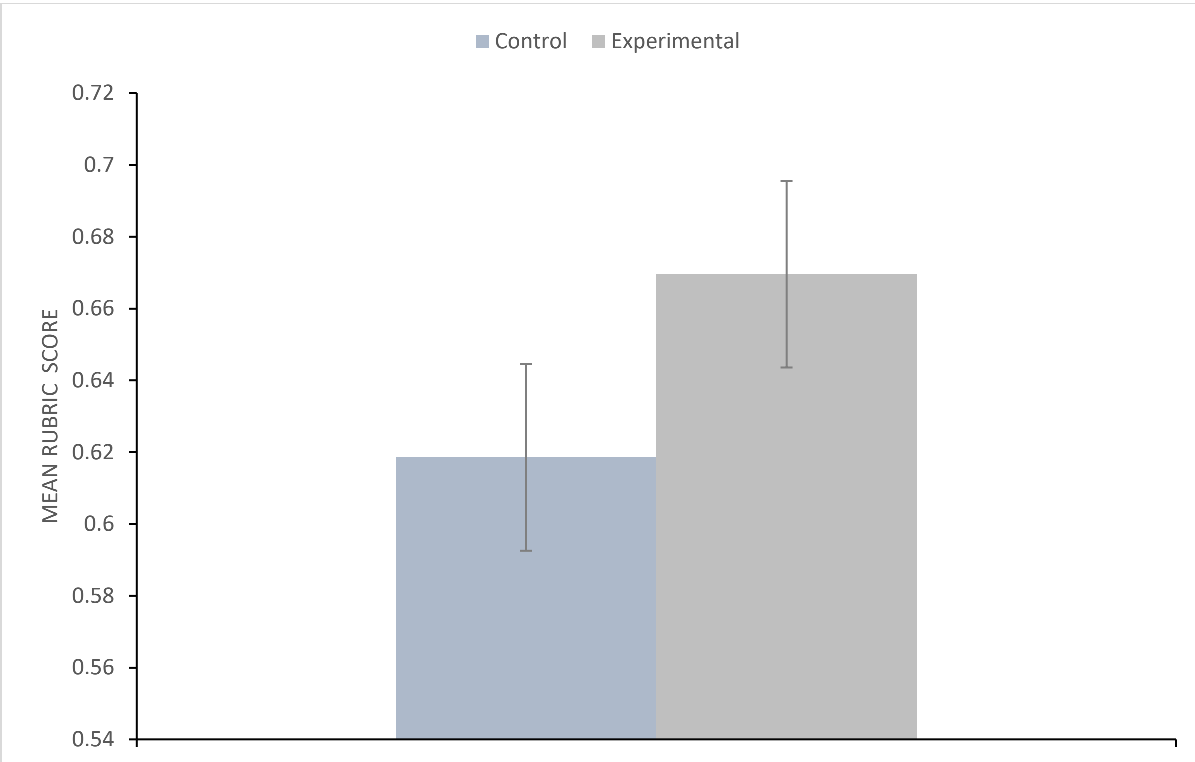

Figure 13: Performance in the simulator for two groups

NASA – TLX Subscales

The NASA – TLX was divided into 6 subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration (see figure 14: NASA – TLX Subscales for Two Groups). The difference between groups and each subscale were analyzed using t tests. The t tests found nonsignificant differences between the groups on all of the subscales: mental demand, t (19) = .272, p = .788, physical demand, t (20) = .815, p = .425, temporal demand, t (20) = .550, p = .589, performance, t (20) = 1.327, p = .199, effort, t (20) = .296, p = .770, frustration, t (20) = .301, p = .767. It should be noted that a negative or lower score on performance indicated the cadet thought he or she had better performance.

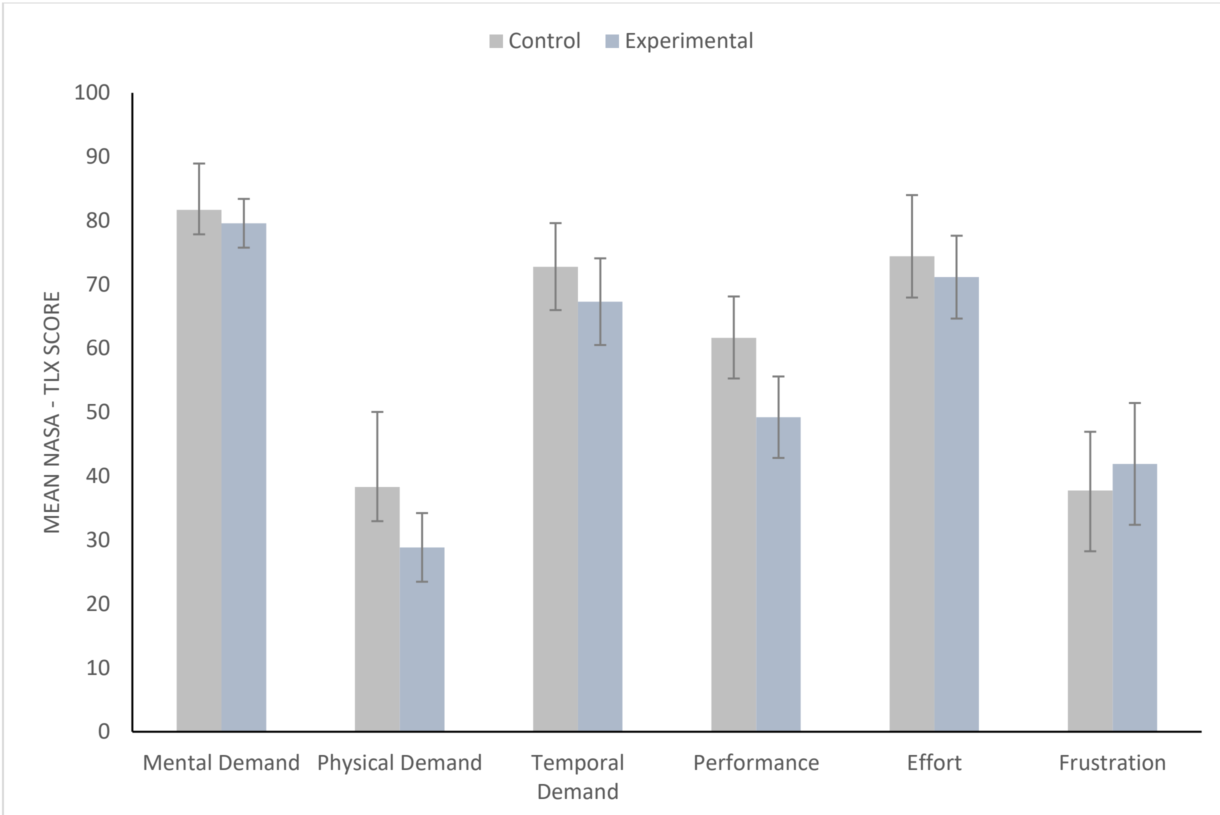

Figure 14: NASA – TLX subscales for two groups

Correlations

The first set of correlations indicate how well the personality measures predict the state anxiety experienced throughout the course (see Table 4 Intercorrelations of Personality and STPI). The anxious thought inventory (AnTI) indicates a disposition towards various forms of worry (Wells, 1994). Its various components tended to intercorrelate negatively with Grit and positively with Test Anxiety and STPIs 1, 4, and 8 which may reflect the impact of stress factors during the week. Test Anxiety also correlated with weeks 1 and 4 of the STPIs as well as with weeks 9, 10 and 11. Weeks 9, 10 and 11 did have several very important tests during them. Test Anxiety had a negative correlation with Grit but no significant relationship with Hardiness. Grit and

Hardiness did not correlate with each other and Hardiness did not correlate with any of personality measures. This may mean that Hardiness measures another component of resilience.

Table 4: Correlations of Personality and STPI

	Measures	1	2	3	4	5	6	7	8	9	10	11
1	AnTI Sum	--										
2	AnTI Social	.93**	--									
3	AnTI Health	.81**	.67**	--								
4	AnTI Meta	.71**	.51*	.35	--							
5	Hardy Sum	-.23	-.1	-.36	-.16	--						
6	Hardy CM	-.07	.06	-.2	-.09	.78**	--					
7	Hardy CO	-.35	-.21	-.38	-.36	.76**	.53*	--				
8	Hardy CH	-.25	-.24	-.23	-.13	.73**	.37	.34	--			
9	Test Anxiety	.47*	.45*	.47*	.23	.12	.15	.06	-.01	--		
10	Grit	-.59**	-.47*	-.35	-.70**	.26	.2	.31	.22	-.46*	--	
11	STPI 1	.63**	.52*	.62**	.46*	-.20	-.15	-.12	-.29	.59**	-.49*	--
12	STPI 2	.24	.36	.01	.13	-.19	.04	-.07	.13	.19	-.09	.30
13	STPI 3	.27	.22	.11	.35	.06	-.04	.16	-.04	.27	-.26	.58**
14	STPI 4	.66**	.51*	.62**	.54**	-.33	-.21	-.24	-.36	.58**	-.50*	.86**
15	STPI 5	.33	.40	.22	.13	-.11	.03	-.10	-.23	.06	-.25	.35
16	STPI 6	.34	.31	.15	.37	.02	.03	-.14	-.04	.15	-.23	.30
17	STPI 7	.32	.12	.40	.40	-.32	-.28	-44*	-.1	.26	-.45*	.37
18	STPI 8	.46*	.28	.33	.62**	-.3	-.23	-.34	-.16	.37	-.69**	.55**
19	STPI 9	.16	.10	-.02	.37	.11	.16	.13	.06	.47*	-.30	.29
20	STPI 10	.25	.24	.14	.25	.00	.03	.04	-.01	.53*	-.35	.36
21	STPI 11	.41	.39	.31	.32	.14	.03	.16	-.09	.63**	-.37	.52*
22	STPI Ave	.57**	.47*	.40	.55**	-.17	-.14	-.12	-.11	.56**	-.55**	.75**

*Note:** $p < .05$, ** $p < .01$, N = 22

	Measures	12	13	14	15	16	17	18	19	20	21	22
1	AnTISum											
2	AnTISocial											
3	AnTIHealth											
4	AnTIMeta											
5	Hardy Sum											
6	Hardy CM											
7	Hardy CO											
8	Hardy CH											
9	Test Anxiety											
10	Grit											
11	STPI 1											
12	STPI 2	--										
13	STPI 3	.48*	--									
14	STPI 4	.38	.68**	--								
15	STPI 5	-.02	.15	.25	--							
16	STPI 6	.14	.30	.38	.62**	--						
17	STPI 7	-.02	.16	.50*	.27	.36	--					
18	STPI 8	.07	.27	.54**	.29	.53*	.59**	--				
19	STPI 9	.20	.26	.44*	.19	.46*	.59**	.50*	--			
20	STPI 10	.18	.27	.50*	.39	.58**	.69**	.42*	.82**	--		
21	STPI 11	.22	.04	.40	.12	.23	.17	.37	.58**	.38	--	
22	STPI Ave	.39	.56**	.82**	.51*	.69**	.67**	.72**	.75**	.79**	.55**	--

*Note:** p < .05, **p <.01, N = 22

Table 5 represents the associations between three different kinds of measures of stress outcomes, i.e., (1) objective performance, (2) subjective stress and workload, and physiological stress expressed in cardiac activity. The simulator performance positively correlated with HRV before the simulation and during the simulation with a trend towards significance in the debrief. The performance score was not correlated with engagement, distress, or worry. The correlation between the performance score on the rubric and the NASA – TLX performance and frustration scores indicated that the better the cadets did the better they thought they did and the less frustrated they felt. HRV and HR were related to distinctly different measures. HR was correlated with pre task worry. Surprisingly, HR was negatively correlated with physical demand. HRV RMSSD was negatively correlated with temporal demand. DSSQ post task distress had a positive correlation with effort, temporal demand, and frustration. Post task engagement was related to both better self-assessed performance scores and effort. Post task worry was only related to mental demand.

Table 5: Correlations of Simulation Variables

Measures	1	2	3	4	5	6	7	8	9
1. Rubric	--								
2. DSSQ Pre Engagement	.03[c]	--							
3. DSSQ Pre Distress	.09[c]	-.37[c]	--						
4. DSSQ Pre Worry	.00[c]	-.47[c]	.35[c]	--					
5. DSSQ Post Engagement	.18[c]	.45[*c]	-.18[c]	-.30[c]	--				
6. DSSQ Post Distress	-.20[c]	-.25[c]	.30[c]	.40[c]	.02[c]	--			
7. DSSQ Post Worry	-.06[c]	-.12[c]	.20[c]	.38[c]	.07[c]	.20[c]	--		
8. NASA – TLX Mental Demand	.08[d]	-.01[d]	.20[d]	-.36[d]	-.12[d]	.09[d]	-.54[*d]	--	
9. NASA – TLX Physical Demand	.34[c]	.11[c]	-.26[c]	-.34[c]	.22[c]	-.26[c]	-.33[c]	.19[c]	--
10. NASA – TLX Temporal Demand	-.03[c]	.04[c]	.15[c]	.26[c]	-.01[c]	.52[*c]	-.17[c]	.42[c]	.23[c]
11. NASA – TLX Performance	-.50[*c]	-.09[c]	.18[c]	-.08[c]	-.45[*c]	.09[c]	-.21[c]	.29[d]	-.09[c]
12. NASA – TLX Effort	-.04[c]	.21[c]	.10[c]	.03[c]	.64[**c]	.45[*c]	.18[c]	.06[d]	.27[c]
13. NASA – TLX Frustration	-.44*[c]	-.32[c]	.35[c]	.11[c]	-.21[c]	.67[**c]	.41[c]	.15[d]	-.42[c]
14. HRV RMSSD 10 Minutes	.52[*b]	-.13[b]	-.11[b]	-.08[b]	.06[b]	-.23[b]	-.27[b]	.08[a]	-.01[b]
15. HR 10 Minutes	-.37[a]	-.31[a]	.28[a]	.65[**a]	-.03[a]	.46[a]	.44[a]	-.37[e]	-.55[*a]
16. HRV RMSSSD Sim	.59[*b]	-.08[b]	-.27[b]	-.22[b]	.11[b]	-.38[b]	-.22[b]	-.01[a]	.15 [b]
17. HR Sim	-.59[*a]	-.26[a]	.14[a]	.51[a]	-.06[a]	.43[a]	.15[a]	-.18[e]	-.54[*a]
18. HRV RMSSD Debrief	.49[b]	-.04[b]	-.28[b]	-.27[b]	.15[b]	-.32[b]	-.30[b]	.02[a]	.13[b]
19. HR Debrief	-.45[a]	-.26[a]	.29[a]	.63[*a]	-.24[a]	.31[a]	.16[a]	-.19[e]	-.52[*a]

Note: *p < .05, ** p < .01, N: a = 15, b = 16, c = 22, d = 21, e = 14

Measures	10	11	12	13	14	15	16	17	18	19
1. Rubric										
2. DSSQ Pre Engagement										
3. DSSQ Pre Distress										
4. DSSQ Pre Worry										
5. DSSQ Post Engagement										
6. DSSQ Post Distress										
7. DSSQ Post Worry										
8. NASA – TLX Mental Demand										
9. NASA – TLX Physical Demand										
10. NASA – TLX Temporal Demand	--									
11. NASA – TLX Performance	.09[c]	--								
12. NASA – TLX Effort	.50[*c]	-.12[c]	--							
13. NASA – TLX Frustration	.07[c]	.37[c]	.21[c]	--						
14. HRV10 Minutes RMSSD	-.53[*a]	-.33[a]	-.28[a]	-.28[a]	--					
15. HR 10 Minutes	.09[a]	.07[a]	.29[a]	.51[a]	-.30[a]	--				
16. HRV Sim RMSSD	-.65[**b]	-.38[b]	-.34[b]	-.36[b]	.95[**b]	-.46[b]	--			
17. HR Sim	.08[a]	-.01[a]	.04[a]	.40[a]	-.27[a]	.74[**a]	-.64[*a]	--		
18. HRV Debrief RMSSD	-.61[*b]	-.29[b]	-.24[b]	-.30[b]	.95[**b]	-.28[a]	.97[**b]	-.44[b]	--	
19. HR Debrief	.10[a]	.24[a]	-.08[a]	.31[a]	-.40[a]	.76[**a]	-.68[**a]	-.86[**a]	-.60[*a]	--

Note: *p < .05, ** p < .01, N: a = 15, b = 16, c = 22, d = 21, e = 14

Table 6 shows how the personality measures predicted subjective stress and workload response. All of the components of the AnTI scale were correlated with DSSQ post task distress (see table 6: Correlations of personality with DSSQ and, NASA – TLX measures during the scenario). The AnTI social component was additionally related to pre task worry. The AnTI measures never correlated with workload measures. Those high in Hardiness CM experienced high physical demand while those high in Hardiness CH rated their performance higher. Strangely the higher the cadets rated themselves in Test Anxiety the better they thought their performance was. Grit was not related to either DSSQ or NASA – TLX scores.

Table 6: Correlations of personality with DSSQ and, NASA – TLX measures during the scenario

Measures	DSSQ Pre-Engagement	DSSQ Pre- Distress	DSSQ Pre- Worry	DSSQ Post- Engagement	DSSQ Post-Distress	DSSQ Post- Worry
AnTI Sum	-.35	.13	.44*	-.05	.55**	.14
AnTI Social	-.35	.12	.46*	-.06	.48*	.2
AnTI Health	-.31	.1	.28	.00	.45*	.05
AnTI Meta	-.18	.14	.30	-.03	.43*	.04
Hardy Sum	.08	.06	.18	.3	-.03	.1
Hardy CM	.03	.24	.22	.16	.21	.06
Hardy CO	-.08	-.11	.34	.07	-.10	.13
Hardy CH	.17	.12	-.09	.35	-.29	.01
Test Anxiety	-.17	.05	.28	.36	.37	.01
Grit	.23	-.26	-.29	.06	-.25	-.29

Note: *p <.05, **p <.01, N = 22, except for NASA – TLX Mental Demand where N = 21

Measures	NASA - TLX Mental Demand	NASA - TLX Physical Demand	NASA TLX Temporal Demand	NASA – TLX Performance	NASA - TLX Effort	NASA - TLX Frustration
AnTI Sum	.05	-.2	.24	-.29	.02	.25
AnTI Social	.03	-.24	.23	-.2	.05	.33
AnTI Health	-.04	.01	.22	-.29	.07	.1
AnTI Meta	.15	-.22	.13	-.26	-.08	.14
Hardy Sum	-.1	-.18	.18	-.17	.34	-.12
Hardy CM	-.13	-.53*	.06	.03	.21	.21
Hardy CO	-.43	-.06	.16	.01	.18	-.25
Hardy CH	.15	.07	.07	-.43*	.24	-.32
Test Anxiety	-.08	.37	.31	-.43*	.44*	.02
Grit	.18	-.09	.08	.32	.03	-.17

Note: *p <.05, **p <.01, N = 22, except for NASA – TLX Mental Demand where N = 21

Personality was generally a weak predictor of performance stress and physiological responses in the simulation, but a few significant correlations were found. A significant correlation between performance in the simulator and Grit, r (22) = -.449, p = .036, was found. It is thought that it was probably due to chance. The AnTI Meta and RMSSD HRV 10 minutes before simulation, r (16) = .542, p = .03, were correlated although worry is generally related to lower RMSSD HRV scores not higher. There were several correlations between Hardiness and HR. Hardiness Sum was correlated with both HR in the final baseline, r (15) = .57, p = .03, and HR 10 minutes before simulation, r (16) = .542, p = .03. The Hardiness CM component was related to HR at several different times: HR during the final baseline, r (15) = .542, p = .037, HR 10 minutes before simulation, r (15) = .610, p = .016, and HR during the simulation, r (15) = .643, p = .010. Hardiness CO was correlated with HR 10 minutes before simulation, r (22) = .535, p = .04, and HR at the final baseline, r (22) = .517, p = .049.

A t test comparing personality scores was conducted to see if the experimental group and the control group were equally stress vulnerable was conducted. Nonsignificant results were found for all the AnTI measures. The t test for AnTI Sum was nonsignificant, t (20) = 1.857, p = .078. The t test for AnTI Social was nonsignificant, t (20) = 1.34, p = .195. The t test for AnTI Health was nonsignificant, t (20) = 1.344, p = .194. Although the AnTI Meta was nonsignificant it trended towards significance, t (20) = 2.03, p = .056. All the AnTI scores were slightly higher for the experimental group than the control group. The t tests found nonsignificant differences on all the Hardiness scores with the control group having slightly higher means than the experimental group: Hardiness Sum, t (20) = .920, p = .368, Hardiness CM, t (20) = 1.192, p = .247, Hardiness CO, t (20) = .475, p = .64, and Hardiness CH, t (20) = .176, p = .862. A t test for

Test Anxiety found a nonsignificant result, *t* (20) = .571, *p* = .574. The experimental group had slightly higher nonsignificant Test Anxiety. A t test for Grit found a nonsignificant result, *t* (20) = 1.897, *p* = .072. The control group had a higher mean than the experimental group. Results tended to indicate that while the differences were nonsignificant the control had more stress resistance than the experimental group.

CHAPTER FIVE: DISCUSSION

Police face mounting pressure and stress from a variety of sources at their jobs. Inability to regulate stress in an effective manner has led to poor performance appraisals and citizen's complaints at the mild end of the consequence spectrum (Patterson et al., 2014) and to death at the severe end. Police need to be able to make life and death (such as shoot/ no shoot) decisions under high stress as complex fast paced situations evolve. Lack of effective self-regulation of the stress responses has been associated with inappropriate decision leading to violence, assault, and even death of innocent people (Haller et al., 2014). Due to the prevalence of stress in police work it is critical for police departments to implement effective stress management techniques. However, given the multiplicity of available techniques it is unclear which methods are the most effective for stress management in the police. The review of stress management techniques reported in the introduction suggested that breathing interventions might be especially effective for police officers.

Hence, this dissertation focused on using a breathing intervention to improve HRV and mitigate stress and thus improve performance for police cadets. Past research efforts have shown high HRV was associated with better stress regulation (Kim et al., 2013), improved cognitive (Johnsen et al., 2003), and physical performance (Choudhary et al., 2016). Other efforts have indicated various methods to successfully increase HRV such as breathing at resonance rate (Lehrer & Eddie, 2013; Lehrer, Vaschillo, & Vaschillo, 2000). This study utilized a simulated police work scenario in which cognitive demands and stress were expected to be high. This study could then investigate factors influencing subjective and objective stress outcomes in the simulation, including exposure to the breathing intervention.

This study looked at predictors of subjective and objective stress outcomes in the simulation. Data confirmed that simulation was a difficult task. This was justified by moderate performance levels (control group M = 62, experimental group M = 67). Given the possible serious consequences of human error, such as shooting an innocent person, in the operational context police officers should be performing close to 100 percent. The simulation also increased stress as evidenced by the decreased HRV in the simulation and increased distress on the DDSQ. A near significant trend was found towards the breathing intervention increasing HRV and reducing stress; however, the intervention did not significantly affect stress levels. HRV levels were associated with performance. As predicted HRV was positively correlated with performance, supporting the value of focusing on HRV in interventions of stress. Some personality predictors of stress response were also identified.

The impact of the breathing intervention was less than anticipated; however, the study could not be run as planned originally due to the impact of Covid-19. During the intervention period there were restrictions placed onto interactions between the researcher and the participants due to the Covid -19 pandemic. Several participants were forced to drop out because their agencies recalled them. This reduced the subject numbers. In addition, many of the experimental group did not consistently practice the breathing intervention once the pandemic prevented the researcher from seeing them in person. Prior to the Covid-19 restrictions the control condition met with the researcher once a week to talk about stress mitigation techniques. They would discuss amongst themselves those techniques. Once the Covid-19 restrictions were in place the meeting were conducted virtually and the general participation dropped. Several subjects dropped out of that group because they felt there was no value in that format. The following sections of this discussion address further several issues related to using the breathing intervention.

This study investigated several issues related to using a breathing intervention to mitigate stress and increase performance. First, it was investigated as to whether breathing had an impact on the physiological, psychological, and performance stress responses during the course. Secondly, it was investigated as to whether breathing had an impact on the physiological, psychological, and performance during the simulation. Thirdly, the dissertation conducted correlational analyses to investigate relationships between various measures of individual differences in stress. As mentioned previously stress is multifaced (Matthews, 2016a). Because personality traits, states, physiology, and characteristics of the task all combine in various ways it can be difficult to determine the extent to which different stress measures are correlated with each other (Matthews et al., 2019). In some instances, they may not be strongly correlated. To address this question the correlations between the different stress measure in the scenario were intercorrelated to see if any relationships could be found despite the small sample size.

Breathing and HRV

Literature reviewed in the introduction suggest that resonance breathing training can lead to increases in HRV (Lehrer et al., 2000; Lehrer et al., 2003). Increased HRV may have benefits including lower stress, better well-being, and better performance in challenging conditions. On this basis it was expected that the experimental group would have greater improvements in their HRV than the control group as training progressed. The experimental group showed an increase in HRV from the initial baseline to the final baseline while the control group showed a decrease in HRV from initial baseline to final baseline. While the changes trended in the expected directions the differences did not reach significance. The middle baseline could not be taken due to the pandemic restrictions. The initial baseline was measured on day one. The final baseline was measured on the same day as the final simulation. Both groups may have had higher stress on the final day knowing they had to complete the simulation later and they were studying for their final exams. This may have resulted in lower HRV scores on the final day than if the baseline had been taken on a day without additional stressors, as it had been at the initial baseline. The control group appeared to be more stressed as evidenced by their decrease in HRV scores than the experimental group whose scores increased. This would seem to imply that the limited breathing engaged in by the experimental group may have some effect on HRV. This breathing intervention has been said to be comparable to the way in which athletes train muscles through exercise (Lehrer & Gevirtz, 2014; Vaschillo et al., 2006). It works in a way similar to decreasing consistency of exercise, decreasing consistency of resonance breathing would result in participants losing some of the gains they had made. Decreasing training should result in a similar phenomenon as the train/detrain paradigm tested in Hansen et al. (2004). Perhaps, had the intervention group continued the intervention as instructed there may have been a significant difference in HRV scores. However, with this result, it is expected that while there may be trends in stress and performance, they won't reach significance but should trend in the correct direction.

Effects of Breathing on Stress Response Changes During the Course

Research has shown that resonance breathing training can influence subjective stress measures (Dziembowskal et al., 2016; Meier & Welch, 2016; Munafo et al., 2016; Wells et al., 2012; Goessl et al., 2017). STPI scores may reflect personality traits as well as the experimental manipulation. One possible concern is that by chance the one group may have been more stress vulnerable than the other group. A t test of averages of personality factors indicated that although the control and experimental groups were not significantly different on the personality factors the experimental group was generally higher on the AnTI measures, and Test Anxiety, while lower in Hardiness measures and Grit.

STPIs were used to measure anxiety over the length of the course and then again on the day of the simulation. Although the results did not reach significance the experimental group appeared to be slightly more anxious on most days than the control group. This could be related to their generally poorer resilience personality factors. Another possibility is that students did not take this particular measurement seriously as they had to take it every week. Many of the weekly STPI scores were correlated with each other, meaning they did not change a lot week to week. There was also the possibility that the experimental group was anxious at this time as they had to report how much they had practiced (or did not practice as the case may be). Again, the breathing group did not stay consistent on their practice which may have impacted the results.

Breathing and Personality Traits Effects on Test Performance

The test scores obtained throughout the course appeared to vary per the individual test. There were no significant differences between the groups. Although the breathing group was generally a little better on tests than the control group, the difference was close and never reached significance. As stated, before the experimental group did not practice correctly the entire time and thus only trended towards a difference in HRV scores. This may have translated into very little of the cognitive advantage that was expected. An additional factor was that in this course cadets must pass all sections to pass the course. If a cadet did not pass one section, he or she could remain in the course but would have to repeat the section in a later course, be fired from their hiring agency, and had to pay for the course themselves. If they passed later the agency would re-hire them. In general, if the cadets were not doing well, they were either encouraged to quit or forced out of the program. This may mean that for this program only the better test takers were still in the program. The average test scores of each participant also did not correlate with any of the HRV scores. That is not entirely surprising considering that HRV varies in real time in response to what is going on. A better way to see if the test scores were impacted by the HRV would have been to take HRV scores just before and during the tests themselves. One subject told the researcher that she had Test Anxiety and that the breathing right before the test was helping her control her anxiety.

Effects of Breathing on Stress Response Changes and Performance During the Simulated Scenario

The simulated scenario had multiple aspects that made it difficult. According to the instructors the simulation was the first time that all the skills learned in the course were put together which made it difficult. Being evaluated should have made the situation even more stressful. Due to the simulators wrap around style it meant the cadets needed to track action on multiple screens including behind them. The simulation was realistic and based on scenarios that happened to officers in the field. Some of the skills such as the taser were only learned the week before. The instructors indicted the scenario was really beyond the cadets' capabilities and should have been very challenging. There were multiple time sensitive decision points that may be based on ambiguous information and their ability to multi-task. For example while looking for suspects and providing cover to other police officers the cadets should also be looking for their own cover, listening to radio chatter for updates, listening to simulated police officers communications, keeping track of police officer and suspects positions and numbers and watching the dog for cues as to where the suspect may be located. In addition, the cadets had to decide if objects held in the hands of suspects were weapons and whether to shoot or not. The stress of the scenario was reflected by drops in HRV scores, moderate levels of performance, and increases in DSSQ worry and distress scores from pre task to post task.

HRV RMSSD measurements were taken 10 minutes before the simulation, during the simulation, and in the debrief after the simulation. Frequency measures were planned; however, equipment problems reduced the number of subjects with good data. Therefore, a decision was made to only analyze RMSSD. RMSSD correlates with the high frequency domain (PNS - vagal influence), and RSA. It is more responsive to beat to beat variations in HR whereas the frequency domain is more influenced by breathing rates. For many of the analyses desired here RMSSD is completely sufficient. However, without the frequency measures there is no way to determine the distribution of HRV activity between the PNS and SNS.

There was a significant effect of phase on the HRV RMSSD scores. The highest scores were found before the simulation. Both the experimental group and the control group showed the same pattern in HRV response to the anticipatory phase, the simulation, and debrief. Both groups had a large drop in HRV during simulation which would be consistent with increased stress expected during the scenario. This indicated a large expenditure in energy geared toward self-regulation (Crameri, Hettiorachchi, & Hanoun, 2021). Both groups had a partial recovery during the debrief. This finding may signal that they were not as stressed during the debrief; however, they were being asked questions about their behaviors and the scenario by the instructions as well as being asked to justify their behaviors, and there was thus still some stress. The debrief was not a true recovery period. While there was not a significant interaction, there was an effect of group on HRV scores that bordered on being significant. The breathing intervention group had higher HRV than the control group in all phases. The lowest HRV for the breathing intervention group never dropped as low as the highest point for the control group. It appeared they had more resources at their disposal. This may mean that even limited breathing practice done by the experimental group allowed them to improve HRV scores a little and maintain higher HRV during stressful events. The initial baseline scores leant additional support for this as the two groups were almost identical at initial baseline. The drop in HRV from the 10 minutes before the simulation to during the simulation was similar in both groups. In addition, both groups had similar recoveries towards their own baselines during the debrief. The drop and subsequent recovery may be representative of the type of stress the cadets were under. The higher HRV exhibited by the breathing group would be indicative of higher autonomic balance (Shaffer & Ginsburg, 2017) and ability to access central autonomic network resources (Crameri et al., 2021). It seems as if having a higher HRV gives the person a better starting point for the resources that need to be allocated to deal with stress. Crameri et al. (2021) found that in a series of simulations with participants that had high, medium, and low HRV that self-regulation abilities decayed over time. After several simulations only the high HRV population was still performing well.   This may indicate that higher HRV may be able to predict performance over time through a series of events. It may be interesting to see how the HRV changes in each of the three stages in this scenario.

The performance results between the two groups still appeared closer than was expected based on the groups alone. Explaining this result must consider that breathing is not the only thing that can increase HRV. Physical fitness levels as seen in Hansen et al. (2004) indicated that aerobic training increased HRV. The two groups had similar HRVs at initial baseline. However, unlike the Hansen et al. (2004) study, the police cadets had a wide range of fitness levels. These ranged from those that indicated they had just started exercising to meet requirements for the academy or those that were currently injured and just trying to stay up with the class to those that competed on a college level or even on an Olympic level prior to entering the academy. Assignment to the experimental or control group tried to take fitness level into account. That kind of range in fitness levels may have negated advantages that should have been seen by the breathing group. It may be that the limited breathing practice the less fit participants in the experimental group engaged in could not negate the advantage of the fitter participants in the control group. It is not clear how the losses of classmates impacted the overall fitness levels and HRV levels of the final groups. It appears that the control group lost at least one of its least fit participants while the control group lost two of its fitter participants. In a study this small that may have made an impact. It is possible that since the breathing group did not practice as they should have that physical fitness became the primary determinant of higher HRV scores. Future studies should have a way to control for fitness level. It would also be helpful in future studies to see if exercise or breathing has a stronger or quicker impact on changing HRV scores.

Another way to measure of stress response was to administer the DSSQ pre task and post task simulation. This allowed the assessment of mood states brought on by the simulator experience. DSSQ state factors are divided into engagement, distress, and worry.

Task engagement (Matthews, 2016b) refers to energetic arousal (as opposed to fatigue), interest in the task, attention or focus on the task, and how motivated and committed the person is to achieve the task. Tasks seen as challenging (not threatening) tend to increase task engagement. For example, a working memory task under time pressure may increase task engagement (Matthews et al., 2000). Positive performance feedback tends to increase task engagement. Fatigue decreases task engagement and is associated with tasks relating to vigilance and monotonous tasks. Task engagement is also correlated with visual search executive processing, facial emotion recognition, and discrimination learning (Matthews, 2016b). Tasks that do not require high attention do not tend to benefit from high task engagement.

There was a significant main effect of phase on engagement. Both groups had a significant increase in their engagement pre task to post task. This would tend to indicate that the cadets saw the task as challenging and exciting. While there was not a significant group effect the breathing group appeared to be more engaged in both cases.

Distress represents a problem responding to the external environment overload and should be viewed in terms of the individual's active attempts to respond to stressors (Matthews, 2016b). Distress is marked by an individual's self-assessment that she or he is failing to cope, feelings of subjective tension, adverse emotional states, feeling of an absence of control and low confidence.

Task demands such as time pressure, multitasking, and ambiguous information tend to be associated with distress. Assessments of threat or lack of control are associated as well. Negative performance feedback increases distress while positive feedback decreases it. Distressed individuals tend to cope by using a maladaptive self-critical emotion focused style.

There was a main effect of phase on the distress scores. Distress was higher for both groups after the simulation. This implies that the simulation scenario was stressful. Time pressure, multitasking and ambiguous information all played a part throughout the simulation. There wasn't a significant difference between the groups on the DSSQ distress scores; however, it should be noted that the experimental breathing group appeared to have slightly higher distress scores than the control group pre task and post task. Based on past research it was expected that the group with lower HRV (the control group) would have also had higher distress in terms of increased tension (Kim et al, 2013). There was no interaction. It is not surprising that both groups had an increase in distress given the nature of the simulation and as both groups went through an event where performance was evaluated by their instructors and then asked to justify their actions. This may have resulted in loss of self-esteem because they felt they did not perform well enough and they were criticized by those they respected, thus higher distress scores. However, instructors also told cadets at the end of the debrief that this was a difficult simulation and that it was beyond their skill level. That may have lowered distress scores. It appeared that the limited breathing was not enough to reduce the levels of distress for the experimental group.

Worry is marked by thoughts that are invasive, and distract the individual from the task (Matthews, 2016b). They are self-focused in nature and often involve the individual's self-esteem. If the task is demanding enough, worry may decrease during that period as focus shifts to the task. If the task is not demanding enough the individual will revert to mind wandering and concerns about self. An example would be monitoring multiple displays. As the number of displays goes up, worry will decrease, however; distress will increase.

There were no significant effects on worry scores as measured by the DSSQ. Both groups increased non-significantly in worry from pre task to post task. The control group appeared slightly more worried than the experimental group. This trend would be in alignment with studies that found that worry has been found to be associated with lower HRV (ChuDuc et al., 2013). The multiple screens and complexity of the scenario may have been enough to mitigate how much worry was experienced during the scenario. So, while the distress scores went up significantly the due to stress the worry scores had a nonsignificant less dramatic increase.

NASA-TLX is a measurement device designed to assess various components of workload (Hart & Staveland 1988). Workload represents an individual's efforts to attain a performance goal and the toll on the individual of those efforts. Workload originates from the interplay of several factors. These include operator characteristics such as expertise, approach, and impressions of the task. It also includes the demands of the task and what conditions are present when the task is performed. Although workload is not a direct measure of stress, Hart and Staveland (1988) indicated that in 16 different experiments stress, ease versus difficulty performing a task, and mental effort were typically correlated with workload.

There were no significant differences between groups on any of the subscales of the NASA TLX. In general, the experimental group had lower NASA – TLX workload scores than the control group and thought they had better performance. Strangely they were also more frustrated. Mental demand, temporal demand, and effort mean scores were all fairly high suggesting the cadets thought they were able to adapt to the stress with effort and task engagement. The moderate frustration scores also suggest that the cadets thought they could adapt to the stress. Since the experimental group did not practice consistently enough to create a significant difference in HRV scores it was expected that the score differences between the groups would be non-significant.

There was a plan to look at shot accuracy**,** reaction time, and shoot/no shoot decisions. This analysis could not be conducted due to missing data. However, there were some interesting observations of data that were collected that could inform future studies. There were three shots taken that were clearly not intended. Two of those shots occurred before the cadet could perceive a weapon in the suspect's hand. Two of them occurred when the cadet should have been trying to deescalate the suicide situation. All three shots were taken by the control group. The cadets were in the lowest 3 for HRV RMSSD scores. These shots were not appropriate and could not be justified in any way. They represent poor decision making. The cadets made the decision to shoot before they had all the information available to indicate a threat. The decision was made so quickly that it was clear that some temporal narrowing occurred as defined by Cohen et al. (2015). It would also support the reports that HRV is associated with self-regulating processes and the ability to suppress unwanted reactions (Crameri, Hettiorachchi, & Hanoun, 2021). The cadets also reported knowing immediately that they had made an incorrect decision. These particular shots, had they occurred in real life, would have resulted in an investigation and are the types of situations that lead to police officers going to trial for murder. This shoot/ no shoot decision should be studied further to see if HRV would predict poor decisions with larger sample sizes. Perhaps a simpler simulation that addressed the problems with assessing performance in the more complex scenario would be appropriate.

A second observation was that those with military or competitive shooting experience did not appear to shoot more accurately, or use fewer shots, than those with low experience. Past research has shown that shot accuracy drops from 90% to 15-50% when moved from a shooting range to a live situation (Hope, 2016). While exact rates were not calculated this result is not unexpected as the cadets often appeared to be using a "pray and spray" strategy. Only one cadet claimed he had any thought at all as to where he was aiming. He indicated he was trying to shoot high to avoid hitting the police dog. While the firearms test is certainly stressful because the students must pass, is conducted with most of the class and observers watching, and is very noisy, it is a different type of stress than the simulator. In the simulator there was no official pass or fail and the class was not watching. However, there was time pressure and decision making that has (although simulated) fatal consequences as well as ambiguous shoot/ no shoot information and multiple things to monitor at the same time. Instructors were there to critique them as well which may have increased anxiety.

Reaction time was difficult to measure in the simulator due to the nature of the story line being told. It was measured from when the cadet indicated he or she perceived the weapon to when he or she fired. It was not measured from when it actually appeared. Each cadet did not necessarily perceive the weapon at the same time. Some saw the weapon in the suspect's hands. Others did not see the weapon and only realized the suspects were armed when the simulated police officers yelled "gun" or when he or she heard shots being fired. Their reaction times were also confounded by some decisions they made prior to the situation where they were called upon to shoot. If a cadet hadn't made the decision to have their weapon up and ready, reaction time was slowed while they drew the weapon. Some cadets became confused and tried to switch weapons after the shooting began. This also led to a delay of their first shot. In the final scenario where the cadet positioned himself or herself on the stage impacted the speed of their final reaction. It impacted whether or not he or she needed to turn to fire or could just fire immediately. These issues with the scenario made reaction time impossible to analyze.

Relationships between Personality Traits for Resilience and Stress Outcomes and Performance

Extensive research shows that some people have more resilient personality traits and others are more stress vulnerable (Duckworth & Quinn, 2009; Jachimowicz et al., 2018; Gould et al., 2002). Resilient personality is important for police work because of the stressfull nature of the job. Stress vulnerable cadets may be in particular need of stress mitigation. In this study we have looked at several relevant traits such as Hardiness, Grit, and Anxiety. This study tested how these traits related to state anxiety during the training period. It also tested whether the personality traits predicted various stress responses to the simulation, including HR, HRV, subjective stress, workload, and performance. Generally the personality traits were not strong predictors of stress outcomes, which may reflect the low statistical power of the study for testing correlations, and the low reliability of some personality scales. However, some associations between personality and stress outcomes were found and those are highlighted in the sections that follow.

People who are hardy tend to react to negative events that occur as a routine part of their life. At the same time, they feel they are in control of their own life, have high commitment towards their work, and have a high tolerance and acceptance for changes and challenges that happen in their lives (Matthews, 2016a). Hardiness is thought to be the determination and fearlessness to apply commitment, control and challenge knowledge and skills to one's life (Maddi, Harvey, Khoshaba, Fazel, & Resurreccion, 2009). Individuals with strong commitment tend to feel that is essential to remain connected to and engaged in the developments in one's life as well as one's social connections. A person with low commitment would tend to become detached and estranged. A person with high control tends to feel it is important to attempt to impact events in one's life as opposed to falling into apathy and helplessness. A person with high challenge tends to view change as normal and something to be embraced as a chance to gain mastery of new knowledge. A person low in challenge would view the changes as unfair infringements on his or her ability to effortlessly maintain well-being and guard against uncertainty. Hardiness has been shown to improve performance in basketball, firefighter programs, GPA, leadership in officer training school, recovery from culture shock and protection against PTSD (Maddi et al., 2009).

It was expected that hardiness would predict lower anxiety during the training course, as well as reduced levels of stress on objective and subjective measures during the simulated scenario. However, this prediction was not strongly confirmed. During the training phase the Hardiness scores did not have a relationship with STPI scores or the average test score. Individual components of Hardiness appeared to correlate with some individual test scores but those seem to be mostly due to chance. During cadet training there were large numbers of dropouts in the first half of the class before the research began. Instructors often encouraged cadets to make the "mature" decision and leave while their home agency could still receive a refund. They also encouraged those who were self-paying to leave before they could not receive a refund. In addition, this study had dropouts. It may be that only those cadets who had high Hardiness to begin with made it until the end and the difference in scores of those that were left were not large enough to see any differences in performance on tests.

In the simulation phase of the study, Hardiness did not correlate with any HRV RMSSD scores. It was suggested that this is because they are appropriate to measuring two different lengths of time (Crameri et al., 2021). Hardiness was appropriate for long periods of time where as HRV RMSSD was more appropriate for 5-minute segments of time. Relationships with resilient personality traits and performance in the simulator were best explained by the concept of *dynamic resilience* rather than traditional resilience. Understanding dynamic resilience requires understanding how it is different from the typical definition of resilience. Usually resilience is viewed as a "stable trait that promotes one's ability to adapt positively in the face of adversity" (Crameri et al., 2021). This quality is related to personality traits such as Grit and Hardiness. The problem is that the personality traits of Grit and Hardiness tend to measure resilience as a response to one long event. Those traits do not address resilience in the moment as it develops in response to the situation. They cannot index the temporal processes or the coping style being employed as challenging event occur. The goal of dynamic resilience is to determine and represent how an individual adjusts and adapts to different conditions throughout the life of an event (Hill, den Hatigh, Meijer, de Jonge, & van Yperen, 2018). This can be over a long period of time or as it is more generally used in the moment such as during task performance. One of the reasons suggested for this impact is the scale of the measures. Resilience is an iterative process that is related to psychological momentum (Hill et al., 2018). Negative momentum moves the individual away from his or her goals which could result in worse and worse performance as the individual decreases effort, engagement and loses self-confidence. The deeper this hole becomes, the more effort is required to get out of it. This momentum could take place over a long period or a short period. An example mentioned by Hill et al., (2018) was that of athletes. A divorce might take months or years to recover from but could influence their performance over time. A lost point in a tennis game might happen over seconds and have an immediate effect on performance. Repeated losses of points or matches builds up over time and creates a pattern.

Using a scale such as Grit and Hardiness to predict performance might be appropriate for long term events or the buildup over time of negative or positive momentum, but for a short-term event such as performance in the simulator, they are unlikely to yield results. Physiological measure especially such as HRV RMSSD may be more appropriate in a short-term event such as a tennis match because they can change quickly in response to the events that are happening. There are HRV measures that might be more appropriate for long term measures that could be investigated to see if they correlate with Hardiness.

Hardiness, however, did have several correlations with HR. Hardiness Sum correlated with HR final baseline. It trended toward correlation with HR 10 minutes before simulation with a p of

.052. The CM component of Hardiness correlated with HR 10 minutes before the simulation, during the simulation, and during the debrief. The CO component of Hardiness correlated with HR final baseline and HR 10 minutes before the simulation. The CH component of Hardiness did not correlate with any of the HR scores. Strangely none of the Hardiness scores correlated with the initial HR which corresponds to when the Hardiness survey was taken. It may be that Hardiness did not correlate with HR under relaxing conditions, but it may correlate only when stress levels have increased. Even the HR at the final baseline may have been under more stressed conditions as the cadets were studying for their finals that day and knew that shortly afterwards, they would be going into the simulation. This seemed contrary to expectations. A study (Weibe, 1991) found that while doing an evaluative threat task with groups of low and high hardy individuals the task itself created elevated HR. Hardiness was correlated with lower HR for high hardy men and higher HR for low hardy men. Hardiness was not correlated with HR in women. It was noted that HR did actually increase before the task and seemed to be linked to anticipating the task. In addition, another study (Contrada, 1989) found that Hardiness was related to blood pressure in men with type A personalites. The challenge component was responsible for all of the relationship to diastolic blood pressure. Clearly Hardiness is not quite straight forward and should be investigated further for mechanisms and gender differences. These correlations should be explored further to see if a different mechanism tends to be involved in Hardiness. It should be noted that as these groups were volunteers it is possible that the final group only had those who had the highest Hardiness to begin with. Due to the small sample size females and males were analyzed together. Future studies should separate them to see if a pattern emerges. This relationship should be investigated further.

The performance measures and Hardiness had nonsignificant correlations. The Hardiness scores did not have a relationship with the average test score. Individual components of Hardiness appeared to correlate with some individual test scores but those seem to be mostly due to chance. In addition, during cadet training there were large numbers of dropouts in the first half of the class. Instructors often encouraged cadets to make the "mature" decision and leave while their home agency can still receive a refund. They also encourage those who are self-paying to leave before they cannot receive a refund. In addition, this study had dropouts. It may be that only those cadets who had high Hardiness to begin with made it until the end and the difference in scores of those that were left were not large enough to see any differences in performance on tests. The same argument would apply to the better test takers. Hardiness did not correlate with performance in the simulator which lends supports for Crameri et al., (2021) argument for dynamic resilience as explained previously. In this argument the length of the event determines the appropriate measurements. Resilience can be measured long term by Hardiness and Grit but short term by physiological measurements.

At the subjective level, Hardiness was associated with some measures of workload. The CM component of Hardiness had a negative correlation with NASA - TLX physical demand. The CH component of Hardiness was correlated with NASA - TLX performance scale. As the cadets rated themselves higher in Hardiness, they also rated themselves higher in performance. This may go along with the Matthews et al., (2019) finding that Hardiness was predictive of response to negative feedback and that those high in Hardiness had coping styles that allowed for more flexible and positive responses to task challenges. Unlike the Matthews et al., (2019) findings, Hardiness did not have any associations with any of the measures of worry or anxiety.

Grit was defined as both "perseverance and passion for long term goals" (Jachimowicz, Wihler, Bailiey, & Galinsky, 2018). Passion occurs when emotions towards an individually meaningful objective are substantial and vigorous enough to drive and focus the individual to act in ways that will allow him or her to achieve the objective.

Like Hardiness, Grit was expected to correlate with reduced stress response throughout the study. Grit had negative correlations with several measures of anxiety including Test Anxiety, the State-Trait Personality Inventory (STPI) and the Anxious Thought Inventory (AnTI) as predicted. Grit – STPI correlations varied across the weeks of the course as further discussed below. However, Grit did not correlate with the test scores.

In the simulation, Grit did not correlate with any HRV RMSSD or HR scores. A negative correlation was found between performance on the rubric and Grit. This was an initially surprising result as it was expected that more Grit would be associated with better performance in the scenario. However, it is explained by dynamic resilience discussed earlier (Crameri et al., 2021) The correlation coefficient was -.449. The direction of the correlation may be due to chance; however, the lack of a positive of the relationship may be meaningful. Jachimowicz et al., (2018) suggested that Grit has had a weak relationship with performance in the past because the Grit scale itself only measure perseverance and not passion. They argued that the Grit scale should be combined with scales that measure passion. Perseverance alone results in a task that is dispiriting and a chore. Adding passion to perseverance changes the task to one that is deeply engaging. Future studies may want to add passion scales into the data collected to see if the correlation becomes stronger and in the correct direction. It is also possible that high Grit helps a person get through a task but doesn't necessarily increase the likelihood of doing well on a short-term task as Matthews et. al. (2019) indicated. Even if a person high in Grit is performing badly, he or she will tend to keep going rather than quit. This may not change the quality of the performance. Grit might be a better predictor of how much practice is done ahead of time in order to prepare for a task. Extra practice may often result in a better performance. In the case of the scenario there was no way for the cadets to practice ahead of time.

Grit did not correlate with the test scores, DSSQ measurements or NASA – TLX measurements. This is in alignment with Crameri et al. (2021)'s dynamic resilience hypothesis, as previously described in relation to Hardiness.

While Grit and Hardiness are thought to confer resilience, traits associated with anxiety are believed to undermine the person's ability to resist stress. The present study used the AnTI (Wells, 1994) as the primary stress vulnerability measure, along with the Westside Test Anxiety Scale (Driscoll, 2007). The Anxious Thought Inventory measures three specific worry components of anxiety (Wells, 1994). Worry has been shown to consistently have a negative impact on performance. The worry focused on in the survey is experienced as negative and not under control of the person experiencing it. The three types of worry addressed are social worry, health worry, and meta worry. Social worry is correlated with public self-consciousness and private self-consciousness. Public self-consciousness relates to the individual's perception and concern for how others are judging him or her. Private self-consciousness is rated to negative introspection. Health worry relates to fear about health and involves private self-consciousness.

Any sort of threat to one's physical well-being, and errors attributing cause to the body's physical responses. Meta worry measures a person's tendency to worry about the fact that he or she worries. This can involve intrusive thoughts and private-self-consciousness. For example, the person may be upset that he or she is having intrusive thoughts about anxiety that are distracting from the task.

The anxiety trait measures were associated to some extent with greater state anxiety, as measured by the STPI, during the course. The variation in trait-state correlations may reflect the influence of external stress factors. STPI scores may also be affected by stress factors that change from week to week and their interaction with personality. The week 1 STPI had a positive correlation with AnTI Sum, AnTI Social, AnTI Health, AnTI Meta, and Test Anxiety. It also had a negative correlation with Grit. The first week may have been stressful due to novel study demands. Week 4 STPI was positively correlated with AnTI Sum, AnTI Social, AnTI Health, AnTI Meta, and Test Anxiety and negatively correlated with Grit. In the fourth week the first group was returning from a two-week break for Christmas and New Year's Day. Stress may have been due to settling back into the routine again. In the second group the fourth week was when the Covid-19 pandemic began to have an impact on the class progression as well as removing classmates from the program. There was a large element of unknown during this week as the decision was still being made as to whether the school should be shut down or not. Week 8 STPI was positively correlated with AnTI Sum, AnTI Meta, and negatively correlated with Grit. During week 8 the first group was having a typical week although possibly gearing up for a lot of testing. The second group was returning from fire-arms training and preparing for a lot of testing. They lost a couple of classmates during this time. Weeks 9 and 10 STPI correlated with

Test Anxiety and there were multiple tests as well as preparing for the final state test. It appears that each time there was a change to the regular routine, those that scored high for anxiety traits and low for Grit became more anxious. The higher Grit appeared to provide more stability and resistance to anxiety despite changes while those with lower Grit were more susceptible to anxiety due to changes. In addition, the average STPI score was positively associated with AnTI Sum, AnTI Social, AnTI Meta, and Test Anxiety and negatively with Grit.

However, the AnTI and Test anxiety scales did not predict test scores reliably. The scales were not significantly correlated with average test score. Occasionally there was a chance negative correlation with a test.

Turning to the simulation data, the AnTI Meta was positively correlated with the HRV RMSSD 10 minutes before the simulations began. The HRV RMSSD 10 min was the anticipatory phase. This was a surprising result as high HRV is usually associated with higher positive emotions and lower negative ones. The AnTI survey was given in the beginning of the experiment while the HRV RMSSD 10 minutes is on the final day. Possibly the changes in HRV RMSSD in the class were able to mitigate AnTI Meta personality tendencies. While the anticipatory phase is when worry was expected to peak it should be noted that the control group's HRV had dropped from the initial baseline and both groups had dropped from the final baseline to the 10 minutes before simulation. According to Crameri et al. (2021) this might indicate that in the presence of the Meta worry the high HRV individuals started to shift resources to deal with the worry. However, low HRV individuals sometimes showed no signs or little indication of stress responses or worry in the same circumstances. That could mean that they decided they did not have the resources to cope and dis-engaged from the task resulting in less worry and stress. Perhaps high HRV allows a person with high Meta worry to function as someone with lower Meta worry would function. This would allow them to use their worry as motivation to perform better as suggested by Matthews et al. (2019). This relationship should be investigated further.

The AnTI measures were also associated with other measures of stress response in the simulation. The Sum of AnTI and all the components of AnTI correlated with DSSQ post task distress. The Anti- Sum and Anti- Social component were both correlated with DSSQ pre task worry. Thus, higher-anxiety individuals were more stress-prone. It is interesting to note that AnTI was associated with worry pre task but distress post task. Possibly anticipating worry interfered with how they coped during the scenario. This may have led to more distress afterwards. This is one example of the multi-faceted nature of stress.

Relationship Between Stress Outcome Measures in the Scenario

The analysis of personality reported in the previous section suggests that personality may have differing relationships with different stress outcome measures. These findings raise the question of whether the different stress and outcome measures are really equivalent to each other, i.e., the multi - faceted nature of stress response. As mentioned in the introduction each person's personality traits, emotional states, physiology, coping abilities and nature of the task integrate to create different responses (Matthews et al., 2019). Different stress responses may not correlate strongly. To address this issue directly this section discusses the relationships between HRV, HR, subjective stress, and performance in the simulated scenario. A simple stress model would suggest that all these measures would be intercorrelated positively or negatively as appropriate, but the multivariate perspective implies they are likely to diverge from each other.

The next set of correlations investigated the relationship between the stress outcome measures taken during the simulated scenario. This would include the relationships between HRV, HR, subjective stress, and performance.

From an applied perspective it is especially important to examine whether performance is associated with stress measures. In police, military, and many other real-life situations the bottom line is human performance. The factors that were related to performance on the rubric are the ones that are the most important for those groups. Since it was suspected that some of the higher HRV cadets could be fitter participants in the control group it is important to verify that high HRV is associated with performance. We also want to know if it is related to any particular measures of subjective stress, given that stress response is multidimensional (Matthews, 2016b).

HRV RMSSD was correlated with performance measures although the rubric correlated with very few measures in general. Only HRV RMSSD during the 10 minutes before, and during the simulation were significantly related to the rubric, while the HRV RMSSD during the debrief was close to significance. The findings from the anticipation phase are in alignment with Haller et al. (2014) who found that higher HRV in the anticipation phase predicted better performance in the simulation. This would indicate that although resilience traits may be helpful to groups facing high stress over time, efforts to increase HRV may still prove useful in dynamic fast paced situations. The behavior of the police seen in their simulation indicated more self-regulation and less unnecessary aggression.

This pattern of high HRV being associated with better performance persisted in this study even though participants varied in a range of other personality traits and stress responses that may have helped or hindered performance. That was in alignment with the results found regarding dental anxiety and HRV (Johnsen et al., 2003). Both the low and the high HRV groups had dental anxiety. But the high HRV group still managed to perform better on a Stroop test even after having that anxiety triggered, than the low HRV group.

HRV RMSSD was also correlated with stress/ workload measures. HRV RMSSD 10 minutes before the simulations, HRV RMSSD during the simulation and HRV RMSSD during the debrief had a negative correlation with NASA – TLX temporal demand. The speed of the simulation should have been the same for everyone except for how quickly they made a decision to act or made a decision to do nothing. The actual speed of the events that should trigger them to act or make a decision remained consistent. Only their perception of the temporal demand changed. One explanation is that having a high HRV somehow helped the cadets respond to the pace of the simulation and thus they perceived the temporal demand as being low. This could indicate that the higher the temporal demand the more stressed the cadet became. This would be in alignment with the performance results in (Johnsen et al., 2003). It is also possible that the reverse is true and that because they were perceiving the temporal demand as low HRV remained high. This seems less likely as the HRV and temporal demand were associated before the event the event began. It is also possible that the higher HRV prior to simulation indicated some resistance to the stress associated with temporal demand by suppressing the stress reaction as suggested by Brosschot, Verkuil, and Thayer (2016). That particular type of suppression is related to another the concept of dynamic resilience which is a relatively new development (Crameri et al., 2021) that proposes that high HRV is associated with a heightened ability to deal with temporal demands and decision making under quickly evolving conditions.

The concept of dynamic resilience, introduced in the previous section, may also explain the role of HRV in short term resilience. One of the ways dynamic resilience tries to capture real time responses in task performance is by measuring the changes in physio-psychological systems at a baseline, through a stressor, and their return to baseline (Crameri et al., 2021). This type of short-term resilience has a relationship with HRV and less with traditional state measures of resilience such as Grit and Hardiness. Crameri et al. (2021) suggested that when the central autonomic network has high temporal processing abilities, it results in real time high dynamic resilience. This can be seen and measured when an individual appears to self-regulate in such a way as to have exceptional organizing and planning abilities during a dynamic decision-making task. These abilities facilitate her or him implementing the ideal route or direction towards goals even when the event is stressful. These abilities also allow the person to regulate the temporal demands of emotions such as suppressing a negative response to stress before it truly manifests. HRV RMSSD is related to the perception of temporal demand and performance in this study and thus is in alignment with dynamic resilience. According to Crameri et al. (2021) HRV is an indication of the resources and efficiency of the self -regulation processes of the prefrontal cortex. It wasn’t clear if the authors thought it was a result of the better ability, marked it, or caused it. If dynamic resilience were the deciding factor in this task HRV would be expected to relate to performance, and measures of temporal demand, but not the trait resilience measures.

Heart rate has been used for measures of stress and biofeedback because it is somewhat under the control of the ANS. However, there has been a move away from it as a stress index because it is influenced by many systems (Parnandi & Gutinerrez-Osuna, 2015) such as physical movement, breath, and circadian rhythm in addition to emotional responses. For example, both anxiety and excitement can result in increases in heart rate or respiratory rate while calmer thoughts tend to lower it. However, the reverse can be true as well. An increase in heart rate or respiratory rate may increase anxiety or excitement while a decrease in heart rate or respiratory rate may serve to calm the individual. Complicating matters is that HR increase could be due to a physical event such as exercise or a cognitive event such as setting a goal (Gellatly & Meyer, 1992). However, HR was related to increases in aggression, attention narrowing, and increased judgements that the actors in the simulation were belligerent and threatening in Haller et al. (2014) and so HR was considered in the analysis to see if it was related to any other factors. The relationship between HR and Hardiness is discussed in another section. Below are some other relationships that emerged.

HR during the simulation was negatively correlated to performance on the rubric. This meant the higher the HR the worse the performance. HR in this study was correlated with some measures of stress. HR, measured 10 minutes before simulation, during simulation, and during the debrief, negatively correlated with NASA - TLX Physical Demand. This was a surprising result as interpreting an increase in HR with increasing physical demand would make more sense. In addition, HR 10 minutes before the simulation and HR during the debrief were both correlated with DSSQ pre worry. Perhaps cadets interpreted all increase in heart rate to their worry because the phases were not physically demanding and mostly involved standing in one location. The relationship between HR and hardiness was discussed previously.

The DSSQ and its relationship to subjective stress, performance and HRV is discussed next. Typically, engagement is related to performance; however, there was no correlation between engagement scores and performance as measured by the rubric. Task engagement has been shown to be useful in tasks requiring vigilance (Matthews et al., 2019), and discrimination behaviors. The scenario in simulation was fast paced and would require low levels of vigilance. However, the students should have engaged in some discrimination behaviors such as determining what was a threat and what wasn't as well as determining places that would provide cover or concealment. This task was the first time for many of these cadets to put together a lot of skills they had learned in their class. Perhaps engagement was unable to make up for lack of experience.

There were some correlations between the DSSQ post task engagement scores and some workload scores. The correlations between DSSQ post task engagement and NASA - TLX performance indicated that the more engaged the cadet was the higher they thought their performance was. Past research has shown that positive feedback increased engagement (Matthews, 2016b) and so the positive feedback on performance from instructors might also increase the cadet's self - assessment of performance. There was also a correlation between DSSQ post task engagement and NASA - TLX effort that may be due to the challenging and game like design of the scenario and the challenge of integrating newly learned mental and physical skills. Instructors indicated that it would be quite difficult for the cadets at their level of experience thus requiring a lot of effort. Another consideration is that the motivation towards task success (Matthews, 2016b) part of task engagement may have also influenced the cadets to put more effort into the difficult tasks. However, being more engaged and putting in more effort doesn't necessarily translate into better performance if the tasks are really beyond the skill level of the cadet.

DSSQ distress scores also correlated with some workload scores. Post task distress scores correlated with NASA – TLX temporal demand, NASA – TLX effort, and NASA – TLX frustration. Distress tends to generally increase under time pressure (Matthews, 2016b) and high workload (Hart & Staveland, 1998). This might have increased the effort needed while lack of better performance results might increase frustration.

Distress does not always result in poorer performance (Matthews, 2016a). For example, it can be modulated by the motivation of the person experiencing it. Distress has been shown to predict poorer performance in multi-tasking scenarios (Matthews et al., 2019). There was not a correlation between the performance rubric and distress even though the scenario included many instances of multi- tasking. All of the tasks of the rubric were added together to come up with a final score which included the scenario itself and the debrief. While the scenario itself involved time pressure, multi-tasking, and display uncertainty the debrief did not. That may explain the lack of correlation between distress and performance on the rubric and possibly the lack or correlation between distress and the HRV. Future studies may want to give the post task DDSQ paperwork in between the simulation and debrief and another after the debrief to better differentiate to what phase the person is reacting.

While distress was not related to performance on the rubric, it was related to temporal demand, which was related to performance. This was a type of recurring pattern that was seen through much of the results. Hill et al. (2018) indicated that this was because resilience is an iterative and multifaceted process. Any and all elements that protect against stress (i.e. Grit) might help the person interpret a situation as a challenge and thus increases the likelihood of positive affect, and better decisions which in turn can lead to higher task engagement which may then contribute to increased effort and commitment which may in turn lead to better performance. This can increase positive psychological momentum and encourage increases in positive affect etc.

DSSQ pre task worry was correlated with HR 10 minutes before the simulation and HR during the debrief but not during the actual simulation. This may lend support to the argument that the task worry led to increases in HR when HR and Hardiness were correlated.

DSSQ post task worry was negatively correlated with NASA – TLX Mental Demand. This result would agree with the idea that as the task becomes more difficult the individual shifts from worry to focusing on the task as suggested by Matthews et al. (2019).

Overall, there was some level of inter-correlation between the different subjective measures of stress and workload. The objective stress measures, i.e., HRV and performance, were more weakly correlated with other stress measures. The correlation between Temporal Demand and

HRV was one notable exception. This lack of convergence between measure is consistent with multivariate perspective of stress. Research might need to take several objective and subjective stress measures to get a full picture of participants' responses to the external demands placed upon them. However, it should be noted that due to the small sample size the variables may in fact be more strongly correlated than the present data indicate.

Limitations

The study had been planned for 30 participants in both the breathing group and the control group. Unfortunately, a combination of dropouts and removals due to Covid -19 resulted in a very low sample size. Correlations are probably weaker than they should be due to the low sample size. There were quite a few more correlations that were trending towards significance that may have changed had a larger sample size been used. This effect was compounded by equipment problems that made some of the HRV recordings unusable.

Given the high variability in fitness levels range-future studies should try to ensure a more limited range of fitness levels. Although an effort was made to ensure both groups had approximately even fitness levels the dropouts may have changed the proportions in each group. Pre task and post task fitness measurements also could not be used. This was due; however, to the weather. The first group to be tested started in fall and ended in February. The second group started in January and ended at the end of May. Fitness tests were conducted by the school outside. The temperature and humidity difference between those two may have confounded any differences that might have been seen otherwise.

Covid-19 limited the researcher's ability to continue face to face meetings and ensure that the breathing group was continuing to practice as instructed. Problems with breathing could have been addressed more readily in person. In addition, members of the control group dropped out because they felt they were not getting anything out of the virtual meetings.

Time was not built into the schedule for the cadets to practice and this hampered ensuring consistent practice. Much of the stress in this course may come from being overwhelmed with a full-time schedule, difficult physical classes, and balancing life requirements with study that needed to be completed outside of class. Adding an additional requirement may have been difficult for them to meet.

The cadets were taught how to do each of the tasks required in the simulation during the class. However, this was the first time they had to put these skills together. The cadets' experience with the skills were very limited and no time was provided to practice putting various skills together. For example, the cadets were only trained on how to use the taser one time the week before. This may have contributed to their confusion and problems with the equipment.

In addition to the problems with the life vest there were other equipment issues. The cameras meant to record performance proved to be borderline useless and could not be used for the second group at all due to the difficulty in setting them up and recording with Covid-19 restrictions.

The simulator did not record when a threat actually appeared and forced the instructors to use an inconsistent method to determine reaction time. In addition, the simulator did not record the event. When an instructor forgot to record reaction time during the debrief it was erased and could not be obtained later.

Originally the plan was to have all the experimental group from one class and all the control from another. Due to low participant numbers this was not possible. Although the groups were aware that different techniques were being used, they were asked not to speak to each other about the particular technique used. They were told that the study was evaluating different techniques and if they shared back and forth there would not be a way to tell which if either technique worked better.

Using a training event meant that the instructors were focused on the learning of the cadets. This meant they might put variations in instructions or the scenario to improve the training that could not be controlled.

The reliability of the surveys was generally close to the scores from previous literature. However, Hardiness had large drops in reliability. Hardiness was especially low on the control subscale.

The complexity of the scenario made it difficult to score. Many actions could be counted as correct as long as the cadet could explain their decision-making process. A simpler scenario with clear shoot no shoot decision points would give a clearer result.

Future Work

The results of this study support more work to determine if breathing at resonance is a viable way to increase HRV with the intent of increasing performance if some methodological changes are made.

Initially, the scenario itself should be made simpler to make grading easier. Possibly a simpler scenario such as found in Patton (2014) would make the analysis easier. This scenario only had shoot/no shoot decisions to make. It made it possible to calculate with much more precision the reaction time, the decision being made, accuracy, and number of rounds fired. It also allowed the length of the scenario to extend quite a bit longer making it possible to calculate decay of resilience over time. More complexity could be added later once initial value of increased HRV due to breathing was established. Future experiments should be conducted that vary the rate of the temporal demand independently of the decision that was made as well as vary the type of task to see how this relationship changes.

There should be time set aside to consistently practice and work with the researcher. This would assure consistent practice and that resonance was being reached consistently. Practicing individually with the researcher may ensure that the technique is being taken more seriously. Although Covid-19 was not something that could be controlled having a set time to practice and meet with the researcher could have been handled on-line had it been established initially. It appears that breathing on one’s own was a lot like exercise and eating correctly. Even if one knows it is good for health and wellness it may not get done consistently unless it is scheduled and mandatory in a day. Although many times the excuse reported was lack of time, very few of group one practiced over their holiday break when they had plenty of time, and few in the second group practiced once the researcher could not check up on them in person despite having precisely the same amount of time available, and few in either group took advantage of the alarm in the breathing application that would remind them to practice.

A group to participate should be selected that would ensure fewer drop out and more participation. A larger N was needed and could not be obtained from this group due to conflicts with their own schedules, the number of students enrolled in the class, and the number of classes that were going on at any one point. Although it would have been desirable to try to get another couple of classes, the fact that only one could be obtained every 5 months meant that if initial numbers were not achieved immediately the study would need to continue for several years to get the numbers needed. Ideally, training groups that may alter scenarios should be avoided to keep assessment of performance consistent.

A technique that did work in this study was to have the researchers participate in cadets' training, which may be used in future field studies. In this case the researcher participated in the physical training, and defense training. Several cadets mentioned that this improved their attitude towards the study because the researcher understood some of their stress rather than just observing them. It was helpful in preventing drop-out. Rates of compliance varied greatly ranging from an average of 25 minutes a week at the low end to 87 minutes a week at the high end. Rates of compliance did fall off once Covid-19 prevented the researcher from meeting in person regularly and participating in their physical training class and defense class. Rates of decreasing practice ranged from 8.25 fewer minutes a week to 56.7 fewer minutes a week.

Investigations exploring whether aerobic exercise or breathing is a more effective at adjusting HRV should be explored to determine which may be most effective. Ensuring that the participants have similar fitness levels to begin with should help determine if the breathing intervention working or not.

Development of human behavior models is important to the military, police, and other high stress fields. Development of training curriculums and systems, development and testing of new equipment, and their impacts on tasks, have all relied on an understanding of human behavior. While extensive psychological research on the impact of stress on performance has been conducted, this research has typically been limited to lab settings. Further, this research commonly investigated the impact of a single stressor at a time (e.g., noise) and assessed performance impacts of stress by using basic cognitive tasks (e.g., working memory tasks). However, in real life, the stress process of professionals (such as police and military) working under high external demands is much more complex and unfolds over an extended period of time. Further, reactions to stress and coping strategies may influence the type and intensity of stressors experienced as events unfold. For example, a police officer's questioning of a suspect might be followed by further events such as the suspect becoming aggressive, trying to flee, and seeking help from associates. Successful coping early in the sequence might successfully de-escalate the confrontation with a suspect and forestall later threats such as being physically attacked. Standard psychological experiments examine task performance in a neutral lab environment in which there is no progression of events, and the participant's coping strategies have only limited impacts at most on external demands. However, methods from the field of modeling and simulation may aid in the capture of the dynamic nature of the stress process in demanding real-life settings. Specifically, human performance models used for training applications can capture something of the complexity of real-life stressors. Such models support simulated environments crafted to impose potentially stressful demands on trainees that allow them to develop cognitive skills and coping strategies generalizable to field settings. Training has also used simulators to reduce costs and focus on the practice of perilous or rarely occurring tasks while improving feedback (Cannon-Bowers & Bowers, 2009). From a model-based perspective, it is important to not only correctly model the attributes of the environment that trigger the use of the desired skill, but also to understand the human abilities and cognition behind the skill (Napier, Best, Patton, & Hodges, 2016).

Information from this study may be used later in studies going on within the Army to develop adaptive training. These studies would incorporate HRV changes during dynamic training tasks to see if they might predict learning rates and perhaps when training should adjust in real time be more or less challenging. Those people with lower HRV may need a less challenging rate of learning while also being encouraged to do things that will increase HRV over time. Even those with higher HRV may need to have simulations adjusted down over time as their resilience starts to deteriorate. These studies will allow a better model of how HRV can be used to allow training and simulations to adapt to each person's needs.

In addition, to HRV, stress factors are important to study in context with different types of tasks and can also be incorporated into studies for adaptive learning. Matthews et al. (2019) indicated stress factors are useful to study because they can be used in training programs to see how they are influencing the person's ability to learn. Assessing correlations between subjective stress, performance, and physiological signs of stress may allow learning programs to adjust to the individual learner as training is going on. The same can be said of task demands, individual differences in personality traits, and in stress mitigation strategies. In the case of police officers this may be expanded to help predict if an officer is still fit for duty.

Although Hardiness wasn't correlated with any HRV scores it was only assessed at the beginning of the experiment. In a group that continues to practice the intervention correctly it would be interesting to see if the Hardiness scores change as a result of the intervention. According to Maddi et al. (2009) Hardiness can be trained with a combination of approaches that are designed to increase commitment, control and challenge. This approach focused on problem solving and coping, creating a social network that is supportive where one can both give and receive help, fostering relationships that are not overly competitive or protective, and learning to take care of one's self in a way that optimizes performance. This included relaxation, nutrition, and exercise. They also helped participants determine if stress levels were too high or low. As part of self-care breathing exercises to regulate HRV and optimize stress responses could be included. It is also possible that changing HRV on its own has a limited impact; however, when combined with other techniques helps a person be in a state that is receptive to the other techniques. If Hardiness or other protective factors were increased, would they impact a series of simulations to help HRV remain high or remain uncorrelated?

Conclusion

Police need to be able to regulate their stress in order to effectively do their jobs. This study looked at a possible way to help police develop this ability using a breathing protocol that aimed to increase HRV, decrease stress, and thus increase performance. Although most of the hypotheses were not strongly supported, possibly due to lack of consistent breathing practice, it appeared that there were still trends in the expected direction. It is thought that the lack of practice in the intervention, as well as the limited sample size, may account for the benefits of breathing not becoming significant. In addition, some correlations were found that would seem to back up previous research and lend support for the idea that this approach could work.

Some stress measures such as the workload associated with temporal demand appeared to negatively correlate with HRV measures before, during, and after the simulation. The anxious thoughts inventory Meta scale, which measures anxiety about worry or intrusive thoughts, was correlated with HRV measures 10 minutes before the simulation started. These results would seem to indicate that further research into manipulating HRV may be a viable way to change performance in tasks with high temporal demand and possibly for people showing high Meta anxiety. The fact that HRV did not correlate with most of the stress measures may indicate that it is only indicative of certain types of stress such as temporal demand. Other physiological measures should be studied in the future to see if they reflect other types of stressors that may impact performance adversely. .

APPENDIX A:
DEMOGRAPHICS QUESTIONAIRE

Demographic Questionnaire

Age: ________ MOS:_____________ Years of military service: __ # of Deployments: ________

ID number___

Please circle the appropriate response to the questions below:

Active Duty: Yes No

Sex: Male Female

______ Years of other police type work

______Do you regularly practice some type of meditation or relaxations technique? What type?

______ Have you ever been a manager for a project or work?

What weapons are you familiar with?

What weapons have you shot?

Have you competed in shooting?

How much range time (in hours) have you had?

How much range time do you expect to have during this course?

APPENDIX B:
ANXIOUS THOUGHTS INDEX

ID number___

Anxious thoughts Inventory (AnTI) Wells 1997

	Almost never	*Sometimes*	*Often*	*Almost always*
1.I worry about my appearance	1	2	3	4
2.I think I am a failure.	1	2	3	4
3. When looking to my future I give more thought to the negative things than the positive things that might happen to me.	1	2	3	4
4. If I experience unexpected physical symptoms I have a tendency to think the worst possible thing is wrong with me.	1	2	3	4
5. I have thoughts about becoming seriously ill.	1	2	3	4
6. I have difficulty in clearing my mind of repetitive thoughts.	1	2	3	4
7. I worry about having a heart attach or cancer.	1	2	3	4
8. I worry about saying or doing wrong things when among strangers.	1	2	3	4
9. I worry about my abilities not living up to other people's expectations.	1	2	3	4
10. I worry about my physical health.	1	2	3	4
11. I worry that I cannot control my thoughts as well as I would like to.	1	2	3	4
12. I worry that people don't like me.	1	2	3	4
13. I take disappointments so keenly that I can't put them out of my mind.	1	2	3	4
14. I get embarrassed easily.	1	2	3	4
15. When I suffer from minor illnesses such as a rash I think it is more serious than it really is.	1	2	3	4
16. Unpleasant thoughts enter my head against my will.	1	2	3	4
17. I worry about my failures and my weaknesses.	1	2	3	4
18. I worry about not being able to cope with life as adequately as others seem to.	1	2	3	4
19. I worry about death.	1	2	3	4
20. I worry about making a fool of myself.	1	2	3	4
21. I think I am missing out on things in life because I worry too much.	1	2	3	4
22. I have repetitive thoughts such as counting or repeating phrases.	1	2	3	4

Please check you have responded to all items. Thank you.

APPENDIX C:
NASA TASK LOAD INDEX (NASA TLX)

ID number____

Mental Demand — How mentally demanding was the task?

Very Low — Very High

Physical Demand — How physically demanding was the task?

Very Low — Very High

Temporal Demand — How hurried or rushed was the pace of the task?

Very Low — Very High

Performance — How successful were you in accomplishing what you were asked to do?

Perfect — Failure

Effort — How hard did you have to work to accomplish your level of performance?

Very Low — Very High

Frustration — How insecure, discouraged, irritated, stressed, and annoyed wereyou?

Very Low — Very High

APPENDIX D:
HARDINESS SCALE

ID number____

HARDINESS SCALE (HS)

Below are statements about life that people often feel differently about. Circle a number to show how you feel about each one. Read the items carefully, and indicate how much you think each one is true in general. There are no right or wrong answers; just give your own honest opinions.

	Not at all true	A little true	Quite true	Completely true
	0	**1**	**2**	**3**
1.	Most of my life gets spent doing things that are worthwhile.			0 1 2 3
2.	Planning ahead can help avoid most future problems.			0 1 2 3
3.	No matter how hard I try, my efforts usually accomplish nothing.			0 1 2 3
4.	I don't like to make changes in my everyday schedule.			0 1 2 3
5.	The "tried and true" ways are always best.			0 1 2 3
6.	Working hard doesn't matter, since only the bosses profit by it.			0 1 2 3
7.	By working hard you can always achieve your goals.			0 1 2 3
8.	Most of what happens in life is just meant to be.			0 1 2 3
9.	When I make plans, I'm certain I can make them work.			0 1 2 3
10.	It's exciting to learn something about myself.			0 1 2 3
11.	I really look forward to my work.			0 1 2 3
12.	If I'm working on a difficult task, I know when to seek help.			0 1 2 3
13.	I won't answer a question until I'm really sure I understand it.			0 1 2 3
14.	I like a lot of variety in my work.			0 1 2 3
15.	Most of the time, people listen carefully to what I say.			0 1 2 3
16.	Thinking of yourself as a free person just leads to frustration.			0 1 2 3

ID Number_____

17.	Trying your best at work really pays off in the end.	0 1 2 3
18.	My mistakes are usually very difficult to correct.	0 1 2 3
19.	It bothers me when my daily routine gets interrupted.	0 1 2 3
20.	Most good athletes and leaders are born, not made.	0 1 2 3
21.	I often wake up eager to take up my life wherever it left off.	0 1 2 3
22.	Lots of times, I don't really know my own mind.	0 1 2 3
23.	I respect rules because they guide me.	0 1 2 3
24.	I like it when things are uncertain or unpredictable.	0 1 2 3
25.	I can't do much to prevent it if someone wants to harm me.	0 1 2 3
26.	Changes in routine are interesting to me.	0 1 2 3
27.	Most days, life is really interesting and exciting to me.	0 1 2 3
28.	It's hard to imagine anyone getting excited about working.	0 1 2 3
29.	What happens to me tomorrow depends on what I do today.	0 1 2 3
30.	Ordinary work is just too boring to be worth doing.	0 1 2 3

APPENDIX E:
GRIT SCALE

ID Number_____

12- Item Grit Scale

Directions for taking the Grit Scale: Please respond to the following 12 items. Be honest – there are no right or wrong answers!

1. I have overcome setbacks to conquer an important challenge.
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

2. New ideas and projects sometimes distract me from previous ones.*
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

3. My interests change from year to year.*
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

4. Setbacks don't discourage me.
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

5. I have been obsessed with a certain idea or project for a short time but later lost interest.*
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

6. I am a hard worker.
   - ❑ Very much like me
   - ❑ Mostly like me
   - ❑ Somewhat like me
   - ❑ Not much like me
   - ❑ Not like me at all

ID number_____

7. I often set a goal but later choose to pursue a different one.*
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

8. I have difficulty maintaining my focus on projects that take more than a few months to complete.*
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

9. I finish whatever I begin.
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

10. I have achieved a goal that took years of work.
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

11. I become interested in new pursuits every few months.*
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

12. I am diligent.
    - Very much like me
    - Mostly like me
    - Somewhat like me
    - Not much like me
    - Not like me at all

APPENDIX F:
STATE TRAIT PERSONALITY INDEX (STPI)

Self-Analysis Questionnaire

STPI Form Y-1

ID number _____

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 feel right now, that is, at this moment. 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 your present feelings.

	Not at all	Somewhat	Moderately So	Very Much So
1. I feel calm	1	2	3	4
2. I am tense	1	2	3	4
3. I feel at ease	1	2	3	4'
4. I feel I am presently worrying over possible misfortunes	1	2	3	4
5. I feel nervous	1	2	3	4
6. I am jittery	1	2	3	4
7. I am relaxed	1	2	3	4
8. I feel worried	1	2	3	4
9. I feel steady	1	2	3	4
10. I feel frightened	1	2	3	4

APPENDIX G:
SHORT DUNDEE STRESS STATE QUESTIONNAIRE (DSSQ)

ID Number_____

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.

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 determined to succeed on the task.	0	1	2	3	4
5. I feel tense.	0	1	2	3	4
6. I am worried about what other people think of me.	0	1	2	3	4
7. Generally, I feel in control of things.	0	1	2	3	4
8. I am reflecting about myself.	0	1	2	3	4
9. My attention will be directed towards the task.	0	1	2	3	4
10. I am thinking deeply about myself.	0	1	2	3	4
11. I feel energetic.	0	1	2	3	4
12. I am thinking about something that happened earlier today.	0	1	2	3	4
13. I expect that the task will be too difficult for me.	0	1	2	3	4
14. I will find it hard to keep my concentration on the task.	0	1	2	3	4
15. I am thinking about personal concerns and interests.	0	1	2	3	4
16. I feel confident about my performance.	0	1	2	3	4
17. I examining my motives.	0	1	2	3	4
18. I feel like I can handle any difficulties I encounter.	0	1	2	3	4
19. I am motivated to try hard at the task.	0	1	2	3	4
20. I am thinking about things important to me.	0	1	2	3	4
21. I feel uneasy.	0	1	2	3	4
22. I feel tired.	0	1	2	3	4
23. I feel that I cannot deal with the situation effectively.	0	1	2	3	4
24. I feel bored.	0	1	2	3	4

DSSQ-3 STATE QUESTIONNAIRE

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 was 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 was determined to succeed on the task.	0	1	2	3	4
5. I felt tense.	0	1	2	3	4
6. I was worried about what other people think of me.	0	1	2	3	4
7. Generally, I felt in control of things.	0	1	2	3	4
8. I reflected about myself.	0	1	2	3	4
9. My attention was directed towards the task.	0	1	2	3	4
10. I thought deeply about myself.	0	1	2	3	4
11. I felt energetic.	0	1	2	3	4
12. I thought about something that happened earlier today.	0	1	2	3	4
13. I found the task was too difficult for me.	0	1	2	3	4
14. I found it hard to keep my concentration on the task.	0	1	2	3	4
15. I thought about personal concerns and interests.	0	1	2	3	4
16. I felt confident about my performance.	0	1	2	3	4
17. I examined my motives.	0	1	2	3	4
18. I felt like I could handle any difficulties I encountered.	0	1	2	3	4
19. I was motivated to try hard at the task.	0	1	2	3	4
20. I thought about things important to me.	0	1	2	3	4
21. I felt uneasy.	0	1	2	3	4
22. I felt tired.	0	1	2	3	4
23. I felt that I could not deal with the situation effectively.	0	1	2	3	4
24. I felt bored.	0	1	2	3	4

APPENDIX H:
RUBRICS

Date______ Time______

Student ID_____

Time debrief start

Time debrief ends

Scenario 1:

Participant can see 3 officers on a single screen. They are standing outside a residence.

Participant is told to go help them.

Participant can hear directions being given to the contact team. Participant is told that he/she will be less lethal option and enter with 2 of the officers.

Dispatch indicates that suspect is under a brown tarp in the backyard. Team proceeds to backyard. The simulation goes from a single screen to a full screen as they enter the backyard.

1. **_____Taser out**
2. **_____Taser turned on**
3. **_____Position**: Proper positioning on stage, to the right, away from the other officers. (T)

Establish initial contact with suspect. Rifle operator is yelling commands at the suspect. Suspect emerges from the tarp and stands up. Suspect has gun in waistband. Suspect makes furtive movements towards weapon and is uncooperative

1. _____Allowed rifle officer to give commands. Did not give conflicting commands (C)
2. _____**Laser** on target
3. _____**Muzzle discipline**. Maintained alignment (T)
4. _____**Position**: Correct distance to target
5. _____Kept less lethal out instead of transitioning to a handgun (DM)
6. _____**Shot** with taser (early, ok, late) (DM)

Simulated officers move to arrest suspect

1.______**Taser** low ready. (T)

2. ______Did **NOT laser** fellow officers. (T)

3. _____**Scanned** for other suspects

Scenario 2

Meet officer in an alley. Participant should provide cover for him. Walk to where the next 3 suspects are hiding. Getting info from helicopters in the area.

Begin walking through alley way following directions of the other officer. Joined by K9 team. They should be lethal cover to K9 until.

______**Firearm out** (DM) (note if it was done late)

______**Muzzle discipline**. (DM)

______**Position** to cover K9 team (DM)

______**Confirm** all commands given/acknowledgement (C)

Approaching perimeter unit. The police car with the officer is facing to the right. There is another officer across the street is also facing right. The team will turn to the right when they get to the corner and approach the house.

______Maintained **lethal cover** (DM)

______Firearm at **low ready** until target is identified

______**Muzzle** discipline

______**Scanned** around corner while moving (T)

_____**Position:** to right of the K-9 unit. Watched K9 unit for clues as to where they are going (T)

Dog indicates suspects are in carport in front of house. Take position outside. Contact officer yells commands at the suspects. Three suspects appear from behind vehicle. Two suspects run to back yard. One ducks back behind vehicle.

_____ **Cover**: At carport move to cover (right). Move behind the parked car. (T)

_____ **On target**: Weapon is pointed at car port specifically at unknown in front of car (up on target with firearm) (T)

_____ **Scan**: Scan down street one time. Should scan door, fence, windows on house. (T)

_____ **Communication**: Cover officer allowed contact officer to give verbal commands (did not give conflicting commands) (C)

Dog is released. Suspect comes out and is attacked by dog. Suspect has gun and shoots. Scenario ends with 2 officers arresting suspect.

_____ **Shot:** Engaged subject (early, ok, late). (T)

_____ **Continue shooting**: until the threat is no longer a threat. There is no set number of rounds.

_____**Stop shooting**: Continuous fire after the suspect is down and not moving would be unacceptable. (DM)

_____**Verbalizes** sight of gun (C)

Scenario 3

In carport. Getting ready to head to backyard. Follow the other officer to back yard.

_____**Confirm** other officers are ok do not need assistance before proceeding to back yard with the other officer. Two suspects went back there. (C)

_____**Scan** area. (T) Look down alley

_____**Position**: Maintain proper spacing /moving away from partner. Location on part of screen left rear screen allows participant to see down the alley while focusing on suspect. (T)

_____ **De-escalation** dialogue with suicidal subject. Use calm tone (c)

_____ **Proper questioning**/ asking where the other subject went/is (C)

_____ **Stay on target** with firearm(T)(DM)

_____ **Shoot** suicide (early, ok, late) (DM)

_____**Shoot** last suspect: (Early, ok, late) (T)

Questions to ask in Debrief

Scenario 1

_____Did the participant notice or identify the lack of available cover. (SA)

_____Did the participant notice gun in suspects waistband (SA)

_____Identified suspect as making furtive movements and being uncooperative (SA)

_____Explained why they did or did not use the taser in a timely manner (SA)

_____Does the participant realize the arrest would not happen this way. The rifle officers wouldn't make the arrest. Articulate who would.

_____What color was the tarp

Scenario 2

_____Aware they are lethal cover for the K-9 unit (SA)

_____Knows how many officers are in the group (SA)

_____At carport- identify where good cover was

_____When did you realize the suspect had a gun

_____How many suspects ran into the back yard?

Scenario 3

_____Did participant notice partner had a rifle malfunction (SA)

_____Did participant know how many suspects were still outstanding at the beginning of the 3rd scenario (2) (SA)

_____Does the participant know there was better cover is back around cover but not available due to the simulator? (SA)

_____Does the tarp provide cover or concealment

_____When did you see the alley to the right

_____When did they shoot suicide suspect, justify the timing and location of the shot

APPENDIX I:
WESTSIDE TEST ANXIETY SCALE

Rate how true each of the following is of you, from extremely or always true, to not at all or never true. Use the following 5 point scale.

5	4	3	2	1
extremely or always true	highly or usually true	moderately or sometimes true	slightly or seldom true	not at all or never true

__ 1) The closer I am to a major exam, the harder it is for me to concentrate on the material.
__ 2) When I study, I worry that I will not remember the material on the exam.
__ 3) During important exams, I think that I am doing awful or that I may fail.
__ 4) I lose focus on important exams, and I cannot remember material that I knew before the exam.
__ 5) I finally remember the answer to exam questions after the exam is already over.
__ 6) I worry so much before a major exam that I am too worn out to do my best on the exam.
__ 7) I feel out of sorts or not really myself when I take important exams.
__ 8) I find that my mind sometimes wanders when I am taking important exams.
__ 9) After an exam, I worry about whether I did well enough.
__ 10) I struggle with writing assignments, or avoid them as long as I can. I feel that whatever I do will not be good enough.

APPENDIX J:
CONTROL CONSENT

UNIVERSITY OF CENTRAL FLORIDA

CONSENT FORM

Title of research study: Enhancing Cardia Regulation and Mitigate Stress in Police Cadets

Investigator: Sam Napier and Gerry Matthews

Key Information: The following is a short summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form.

Why am I being invited to take part in a research study?

We invite you to take part in a research study because the police are interested in reducing stress for their members. Focus in this study will be on stress and performance in police cadets. You have been asked to take part in the research study because you are a police cadet. You must be police cadet attending Valencia College, School of Public Safety and be 18 or older.

Why is this research being done?

The purpose of this study is to evaluate different techniques to alleviate physiological and subjective stress responses. The study will evaluate whether these techniques may influence cardiac regulation and the performance of police cadets on a series of cognitive and physical tests included in their curriculum, and on a simulated operational training scenario given at the end of your course. It also aims to test whether personality traits associated with resilience predict heart functioning and performance during training.

How long will the research last and what will I need to do?

We expect that you will be in this research study for the duration of your course. We will record psychophysiological responses linked to stress during the study. We will do this at three baseline recording sessions during your course, during your formal sessions, and during the simulated operational training scenario. We will record data on your cardiovascular functioning and skin conductance using two devices: a wristband and a vest containing sensors worn next to the skin. The vest is not used during the weekly sessions. We will assist you with fitting the devices when needed. We will also ask you to complete surveys on your stress levels soon after beginning the course, at the baseline recording sessions, in practice sessions, and during the simulated scenario. Finally, we are interested in your cognitive functioning and performance. We will ask you to provide us with your test scores from your course using an ID number. We will also evaluate your performance during the simulated operational scenario. You will be recorded on video and audio during the scenario to help the researcher evaluate your performance. We will ask you to provide us with the written feedback from your instructors. The final operational training simulation will be held in non-class time. It will not impact your grade or standing in the course. More detailed information about the study procedures can be found under "What happens if I say yes, I want to be in this research?"

Is there any way being in this study could be bad for me?

There are no foreseeable risks or discomforts other than those normally encountered in the daily lives of healthy persons. There is a small risk that people who take part in the simulated operational scenario will develop what is ordinarily referred to as simulator sickness. It occurs once in a while to people who are exposed to prolonged continuous testing in simulated environments. Symptoms consist of nausea and a feeling of being light-headed. The risk is mitigated by the use of a fixed-base simulator and the your ability to freely move within the simulator and minimal sudden changes in the visual scene. There are no foreseeable risks associated with recording of physiological measures.

Will being in this study help me anyway?

We cannot promise any benefits to you or others from your taking part in this research. However, effects of participation include a decrease in stress levels and an increase in performance

What happens if I do not want to be in this research?

Participation in research is completely voluntary. You can decide to participate or not to participate.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

What should I know about a research study?

- Someone will explain this research study to you.
- Whether or not you take part is up to you.
- You can choose not to take part.
- You can agree to take part and later change your mind.
- Your decision will not be held against you.
- You can ask all the questions you want before you decide.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team: at samnapier@knights.ucf.edu or Dr. Gerry Matthews at gmatthew@ist.ucf.edu. This research has been reviewed and approved by an Institutional Review Board ("IRB"). You may talk to them at 407-823-2901or irb@ucf.edu if:

- Your questions, concerns, or complaints are not being answered by the research team.
- You cannot reach the research team.
- You want to talk to someone besides the research team.
- You have questions about your rights as a research subject.
- You want to get information or provide input about this research.

How many people will be studied?

We expect up to 100 people will be in this research study.

What happens if I say yes, I want to be in this research?

You will be asked to perform 7 activities over the course of your program. Interactions with researchers will take place at Valencia College, School of Public Safety typically after class. The simulator session may be scheduled on a non-class day.

1. Complete initial surveys (30 minutes).
2. Be fitted with an Equivital Eqo2 Life Monitor to assess electrocardiogram (ECG). (30 minutes)

A locker room will be provided to change in privacy without a researcher present.
Following fitting, a researcher will ensure proper fit and that the data box is in the correct

location. Female participants will always be checked by a female researcher; male participants will be given the option of being checked by either a male or female researcher.
The Equivital EQ02 LifeMonitor is a lightweight sensor belt (Figure1) with embedded sensors. It provides non-invasive measurement of multiple physiological responses. The sensors record your heart beats, skin temperature, skin conductance, O2 saturation, and respiration rate. The sensor sits in a pocket built into the LifeMonitor (Figure 1) vests and plugs directly into it. Sensors connect on the inside behind the gray patch on the side of the chest. After each use, the Equivital data box will be wiped clean with an isopropyl alcohol swab as an antiseptic cleanser.


Figure 1. Equivital EQ02 Life Monitor - Sensors connect on the inside behind the grey patch, just on the side of the chest.
Once the shirt is on your body and the researcher is satisfied with the fit and data box location, the researcher will record the time, shirt size, box number, your ID number, and date.
3. Be fitted with an Empatica E-4 wrist band to record heart rate and skin conductance. This is a lightweight wristband designed for research studies with sensors for measuring heart rate, and skin conductance. Each wristband will be labeled with a number. This will be recorded with your ID number and session and time. The researcher will ensure each wristband is worn correctly and is recording accurately.
4. Provide baseline measurements of physiological signals (10 minutes) on 3 occasions. This will be done first at the beginning of the study, at least 4 weeks after the formal sessions begin and once more before the final scenario. You will be fitted with the LifeMonitor and E4 wristband. You will then sit and relax for 10 minutes in a room, with dimmed lights. During this time, your physiological responses will be recorded.
5. Once a week (with exceptions for class schedule and holidays) take a mood survey and wear E-4 Empatica wrist band for 10 minutes while looking at magazines.
6. Take part in a simulation at the end of the study to assess performance in an operational environment (60 minutes). Your instructors have set up this training simulation to be representative of your job. Typically, you would find out the details of a situation from dispatch just before you engaged. This simulation will mimic this. You will be briefed by a simulated dispatch as to the nature of the situation just before you enter the simulation. The situation may require you to draw and use a simulated weapon. You will then take further instructions from

simulated teammates and updates from dispatch as the situation You may be audio and video recorded during this portion of the study to help instructors and the researcher grade your performance. If you are recorded as part of this study the recordings will be kept in a locked, secure place. Audio and video with identifiable information will be deleted after data analysis. All identifiable data and codes will be destroyed once analyzed, typically a month after your last activity.

Upon arrival at the simulation facility you will put on the Life Vest and Empatica E-4 wrist band, with assistance from the researcher. The researcher will take baseline physiological. You will then participate in a 10-minute simulated operational scenario designed to assess performance on cognitive and physical skills appropriate to law enforcement. You will complete a stress survey immediately before and after performance.

Training officers (instructors for the course) will use a rubric and after action review to provide you with feedback. You will be asked to provide the written portion to the researchers after you receive feedback. You will ensure your name is not on the form and that your ID number is. Your performance will have no impact on your grade or status in your course.

7. You will have tests as part of your scheduled course activities most weeks. The researcher will ask you to provide your test scores the week they become available. The test score will be recorded together with your ID number. (2 minutes whenever formal sessions are held)

What happens if I say yes, but I change my mind later?

You can leave the research at any time. Withdrawing from the study will not affect your course evaluations or standing with Valencia College in any way.

All your data will be analyzed without reference to the name or identity of the individual. All audio and video recordings will be transcribed to remove identifiable information for data analysis. These recordings will be deleted following data analysis, typically within one month of the recording being made. Data files for you will be coded using an arbitrary numeric identifier so that your identity will be protected. These de-identified data will be stored electronically on an external hard drive stored in a locked laboratory at IST for a period of at least 5 years and may be reanalyzed at either IST or ARL after completion of the study for publication purposes.

Is there any way being in this study could be bad for me?

There is a small risk that people who take part will develop what is ordinarily referred to as simulator sickness. It occurs once in a while to people who are exposed to prolonged continuous testing in simulated environments. Symptoms consist of nausea and a feeling of being light-headed. The risk is minimized as a result of the short duration of each session in the simulator. If you experience any of the symptoms mentioned, please tell the researcher and remain seated until the symptoms disappear.

There are no foreseeable risks associated with the physiological sensors. Sensors do not alter the body in any way. Sensors will be cleaned with an alcohol swab between uses.

What happens to the information collected for the research?

We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization. We will limit your personal data collected in this study to people who have a need to review this information. In addition, because this research is sponsored by the U.S. Army Research Laboratory, the Army Human Research Protections Office is eligible to review the research records. Data will be secured in locked cabinets and password-protected computers at the Institute for Simulation and Training (IST) and disposed of following IRB protocol, which includes the shredding of all documents and proper deletion of electronic information. If identifiers are removed from your identifiable private information that are collected during this research, that information could be used for future research studies or distributed to another investigator for future research studies without your additional informed consent.

What else do I need to know?

This research is being funded by Army Research Laboratory

Signature Block for Capable Adult

Your signature documents your permission to take part in this research.

Signature of subject

Date

Printed name of subject

Signature of person obtaining consent

Date

Printed name of person obtaining consent

APPENDIX K:
EXPERIMENTAL CONSENT

UNIVERSITY OF CENTRAL FLORIDA

CONSENT FORM

Title of research study: A Breathing Intervention to Enhance Cardiac Regulation and Mitigate Stress in Police Cadets
Investigator: Sam Napier and Gerry Matthews
Key Information: The following is a short summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form.

Why am I being invited to take part in a research study?

We invite you to take part in a research study because the police are interested in reducing stress for their members. Focus in this study will be on stress and performance in police cadets. You have been asked to take part in the research study because you are a police cadet. You must be a police cadet attending Valencia College, School of Public Safety and be 18 or older.

Why is this research being done?

The purpose of this study is to investigate a breathing technique to alleviate physiological and subjective stress responses. The study will evaluate whether this technique may influence cardiac regulation and the performance of police cadets on a series of cognitive and physical tests included in their curriculum, and on a simulated operational training scenario given at the end of training. It also aims to test whether personality traits associated with resilience predict heart functioning and performance during training.

How long will the research last and what will I need to do?

We expect that you will be in this research study for the duration of your course. You will be trained in the use of a phone-based pacer that will assist you in learning a breathing technique that may reduce stress. After an initial 30-minute training session, we will ask you to participate in weekly practice sessions, each lasting 20 minutes. We will also invite you to practice at home for 20 min per day. This can be broken up in to smaller session (for example 4 five-minute sessions). We will record psychophysiological responses linked to stress during the study. We will do this at three baseline recording sessions during your course, during formal practice, and during the simulated operational scenario. No data will be recorded during home practice. We will record data on your cardiovascular functioning and skin conductance using two devices: a wristband and a vest containing sensors worn next to the skin. The vest is not used during practice. We will assist you with fitting the devices when needed. We will also ask you to complete surveys on your stress levels soon after beginning the course, at the baseline recording sessions, in practice sessions, and during the simulated scenario. Finally, we are interested in your cognitive functioning and performance. We will ask you to provide us with your test scores from your course using an ID number. We will also evaluate your performance during the simulated operational scenario. You will be recorded on video and audio during the scenario to help the researcher grade your performance. The final operational training simulation will be held in non-class time. It will not impact your grade or standing in the course.

More detailed information about the study procedures can be found in the section below on "What happens if I say yes, I want to be in this research?"

Is there any way being in this study could be bad for me?

There are no foreseeable risks or discomforts other than those normally encountered in the daily lives of healthy persons. There is a small risk that people who take part in the simulated operational scenario will develop what is ordinarily referred to as simulator sickness. It occurs once in a while to people who are exposed to prolonged continuous testing in simulated environments. Symptoms consist of nausea and a feeling of being light-headed. The risk is mitigated by the use of a fixed-base simulator and the your ability to freely move within the simulator and minimal sudden changes in the visual scene. There are no foreseeable risks associated with recording of physiological measures.

Will being in this study help me anyway?

We cannot promise any benefits to you or others from your taking part in this research. However, possible effects of participation include a decrease in stress levels and an increase in performance.

What happens if I do not want to be in this research?

Participation in research is completely voluntary. You can decide to participate or not to participate.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

What should I know about a research study?

Someone will explain this research study to you.
Whether or not you take part is up to you.
You can choose not to take part.
You can agree to take part and later change your mind.
Your decision will not be held against you.
You can ask all the questions you want before you decide.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team: at samnapier@knights.ucf.edu or Dr. Gerry Matthews at gmatthews@ist.ucf.edu. This research has been reviewed and approved by an Institutional Review Board ("IRB"). You may talk to them at 407-823-2901or irb@ucf.edu if:

Your questions, concerns, or complaints are not being answered by the research team.
You cannot reach the research team.
You want to talk to someone besides the research team.
You have questions about your rights as a research subject.
You want to get information or provide input about this research.

How many people will be studied?

We expect up to 100 people will be in this research study.

What happens if I say yes, I want to be in this research?

You will be asked to perform 10 activities over the course of your program. Interactions with researchers will take place at Valencia College, School of Public Safety typically after class. The simulator session may be scheduled on a non-class day.

The intervention consists of training individuals to breath at their resonance rate. Once the resonance rate is determined, the breathing intervention consists of training in breathing at the individual's resonance breath rate for 20 minutes one time a week and practice for twenty minutes each day on their own. You will receive instruction on how to breathe diaphragmatically. They will have one formal session a week to practice with the researcher and receive feedback to improve technique if required. You will have a breathing pacer application downloaded onto their phone. The pacer will be set to your resonance breath rate. It acts as a metronome indicating when you are to inhale and exhale. This will help you to maintain the correct breath rate both in formal sessions and when they practice on their own. It will also track progress in regulating breathing in between formal sessions. The sequence of activities is as follows:

1. Complete initial surveys (30 minutes).
2. Download a pacer, the Coherence Pro app, on to your IOS (Apple) or Android phone to assist you in learning the breathing technique. The Coherence Pro does not have access to anything else on your phone. The pacer is a display that will indicate when you should be inhaling and exhaling to accomplish "resonance breathing", a breathing rate that improves cardiovascular function and may reduce stress. The researcher will purchase the app and assist with downloading and using the app. Coherence Pro also keeps a record of practice and scores that will be given to the researcher once a week. (10 minutes).
3. Be fitted with an Equivital Eqo2 Life Monitor to assess electrocardiogram (ECG). (30 minutes)

A locker room will be provided to change in privacy without a researcher present. Following fitting, a researcher will ensure proper fit and that the data box is in the correct location. Female participants will always be checked by a female researcher; male participants will be given the option of being checked by either a male or female researcher.

The Equivital EQ02 LifeMonitor is a lightweight sensor belt (Figure1) with embedded sensors. It provides non-invasive measurement of multiple physiological responses. The sensors record your heart beats, skin temperature, skin conductance, O2 saturation, and respiration rate. The sensor sits in a pocket built into the LifeMonitor (Figure 1) vests and plugs directly into it. Sensors connect on the inside behind the gray patch on the side of the chest. After each use, the Equivital data box will be wiped clean with an isopropyl alcohol swab as an antiseptic cleanser.

Figure 1. Equivital EQ02 Life Monitor - Sensors connect on the inside behind the grey patch, just on the side of the chest.

Once the shirt is on your body and the researcher is satisfied with the fit and data box location, the researcher will record the time, shirt size, box number, your ID number, and date.

4. Be fitted with an Empatica E-4 wrist band to record skin conductance and heart rate. This is a lightweight wristband designed for research studies with sensors for measuring heart rate, skin conductance and heart rate. Each wristband will be labeled with a number. This will be recorded with your ID number and session and time. The researcher will ensure each wristband is worn correctly and is recording accurately.

5. Provide baseline measurements of physiological signals (10 minutes) on 3 occasions. This will be done first at the beginning of the study, at least 4 weeks after formal sessions began, and once more before the final scenario. You will be fitted with the LifeMonitor and E4 wristband. You will then sit and relax for 10 minutes in a room, with dimmed lights. During this time, your physiological responses will be recorded.

6. Complete a session to determine resonance breath rate (30 minutes).
You will wear Life Monitor and Empatica E4 wristband. The researcher will train you to breathe and to use the Coherence Pro pacer on your phone to pace your breathing. The researcher will determine your ideal breathing rate (your “resonance” rate and explain how you can practice on your own.

7. Take part in formal practice sessions once a week (20 minutes).
Once a week you will be asked to take part in a formal session with the researcher. During this session you will complete a stress questionnaire.
You will then breathe at your previously determined resonance rate for 20 minutes. You will receive feedback based on the researcher’s observations of your breathing technique. You will also provide the record of their practice sessions as recorded by the Coherence Pro application to the researcher.

8. Practice breathing technique daily with aid of the Coherence Pro pacer. Coherence Pro will automatically record sessions. (20 minutes daily).
You will practice breathing for a minimum of 20 minutes a day. Scheduling of practice is flexible. Practice can be broken into 4, five-minute segments (for example) or longer segments so long as the minimum total of 20 minutes is reached. You may practice at home, or on certain days in the classroom. Home session practice will be recorded by the Coherence Pro application. Recorded practice should be shown to the researcher once a week to demonstrate compliance. Monday-Thursday the researcher will be at the classroom at the end of the day to provide formal sessions with you. If you do not have a formal session on a particular day you are welcome to attend and breathe with the group if you desire.

9. Take part in a training simulation at the end of the study to assess performance in an operational environment (60 minutes). Your instructors have set up this training simulation to be representative of your job. Typically, you would find out the details of a situation from dispatch just before you engaged. This training simulation will mimic this. You will be briefed by a simulated dispatch as to the nature of the situation just before you enter the simulation. The situation may require you to draw and use a simulated weapon. You will then take further instructions from simulated teammates and updates from dispatch as the situation unfolds. You may be audio and video recorded during this portion of the study to help the researcher grade your performance. If you are recorded as part of this study the recordings will be kept in a

locked, secure place. Audio and video with identifiable information will be deleted after data analysis. All identifiable data will be destroyed once analyzed typically a month after your last activity in the study.

Upon arrival at the simulation facility you will put on the Life Vest and Empatica E-4 wrist band, with assistance from the researcher. The researcher will take baseline physiological. You will then participate in a simulated operational training scenario designed to assess performance on cognitive and physical skills appropriate to law enforcement. You will complete a stress survey immediately before and after performance.

Training officers (instructors for the course) will use a rubric and after action review to provide you with feedback. You will be asked to provide the written portion to the researchers after you receive feedback. You will ensure your name is not on the form and that your ID number is. Your performance will have no impact on your grade or status in your course.

10. You will have tests as part of your scheduled course activities most weeks. The researcher will ask you to provide your test scores the week they become available. The test score will be recorded together with your ID number. (2 minutes during formal sessions)

What happens if I say yes, but I change my mind later?

You can leave the research at any time. Withdrawing from the study will not affect your course evaluations or standing with Valencia College in any way.

All of your data will be analyzed without reference to the name or identity of the individual. All audio and video recordings will be transcribed to remove identifiable information for data analysis. These recordings will be deleted following data analysis, typically within one month of the recording being made. Data files for you will be coded using an arbitrary numeric identifier so that your identity will be protected. These de-identified data will be stored electronically on an external hard drive stored in a locked laboratory at IST for a period of at least 5 years and may be reanalyzed at either IST or ARL after completion of the study for publication purposes.

Is there any way being in this study could be bad for me? (Detailed Risks)

There is a small risk that people who take part will develop what is ordinarily referred to as simulator sickness. It occurs once in a while to people who are exposed to prolonged continuous testing in simulated environments. Symptoms consist of nausea and a feeling of being light-headed. The risk is minimized as a result of the short duration of each session in the simulator. If you experience any of the symptoms mentioned, please tell the researcher and remain seated until the symptoms disappear.

There are no foreseeable risks associated with the physiological sensors. Sensors do not alter the body in any way. Sensors will be cleaned with an alcohol swab between uses.

What happens to the information collected for the research?

We cannot promise complete secrecy. Organizations that may inspect and copy your information include the IRB and other representatives of this organization. We will limit your personal data collected in this study to people who have a need to review this information. In addition, because this research is sponsored by the U.S. Army Research Laboratory, the Army Human Research Protections Office is eligible to review the research records. Data will be secured in locked cabinets and password-protected computers at the Institute for Simulation and Training (IST) and disposed of following IRB protocol, which includes the shredding of all documents and proper deletion of electronic information. If identifiers are removed from your identifiable private information that are collected during this research, that information could be used for future research studies or distributed to another investigator for future research studies without your additional informed consent.

What else do I need to know?

This research is being funded by Army Research Laboratory

Signature Block for Capable Adult

Your signature documents your permission to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

APPENDIX L:
INSTURCTOR CONSENT

CONSENT FORM

Title of research study: A Breathing Intervention to Enhance Cardiac Regulation and Mitigate Stress in Police Cadets
Investigator: Sam Napier and Gerry Matthews
Key Information: The following is a short summary of this study to help you decide whether or not to be a part of this study. More detailed information is listed later on in this form.

Why am I being invited to take part in a research study?

We invite you to take part in a research study because the police are interested in reducing stress for their members. Focus in this study will be on stress and performance in police cadets. You have been asked to take part in the research study because you are a police instructor. You must be a police instructor at Valencia College, School of Public Safety and be 18 or older.

Why is this research being done?

The purpose of this study is to investigate a breathing technique to alleviate physiological and subjective stress responses. The study will evaluate whether this technique may influence cardiac regulation and the performance of police cadets on a series of cognitive and physical tests included in their curriculum, and on a simulated operational training scenario given at the end of training. It also aims to test whether personality traits associated with resilience predict heart functioning and performance during training. One group of cadets will practice the breathing technique during their course; a second, control group will not.

How long will the research last and what will I need to do?

This research study will last for the duration of the course. In addition to your regularly scheduled activities as an instructor, which are not part of this study, you will also contribute to a session in which cadet participants perform in the VirTra simulator, on a voluntary basis. This operational training simulation will be held in non-class time. It will not impact the cadet's grade or standing in the course. You will give cadets instructions for performance and watch each cadet perform in a scenario. You will use a rubric to provide feedback to the cadet as well as an after-action review Cadets will be invited to give the rubric with the feedback on it and their ID number to the researchers for analysis. They will be reminded by the researcher that they are under no obligation to provide this information. Data from the final simulation task in the VirTra at the end of the course will be used by the researchers in this study, to assess performance on cognitive and physical skills appropriate to law enforcement.
More detailed information about the study procedures can be found in the section below on "What happens if I say yes, I want to be in this research?"

Is there any way being in this study could be bad for me?

There are no foreseeable risks or discomforts other than those normally encountered in the daily lives of healthy persons.

Will being in this study help me anyway?

We cannot promise any benefits to you or others from your taking part in this research.

What happens if I do not want to be in this research?

Participation in research is completely voluntary. You can decide to participate or not to participate.

Detailed Information: The following is more detailed information about this study in addition to the information listed above.

What should I know about a research study?

Someone will explain this research study to you.
Whether or not you take part is up to you.
You can choose not to take part.
You can agree to take part and later change your mind.
Your decision will not be held against you.
You can ask all the questions you want before you decide.

Who can I talk to?

If you have questions, concerns, or complaints, or think the research has hurt you, talk to the research team: at samnapier@knights.ucf.edu or Dr. Gerry Matthews at gmatthews@ist.ucf.edu. This research has been reviewed and approved by an Institutional Review Board ("IRB"). You may talk to them at 407-823-2901or irb@ucf.edu if:

Your questions, concerns, or complaints are not being answered by the research team.
You cannot reach the research team.
You want to talk to someone besides the research team.
You have questions about your rights as a research subject.
You want to get information or provide input about this research.

How many people will be studied?

We expect up to 100 people will be in this research study. That is to account for those who drop out. We need 30 in the control and 30 in the experimental.

What happens if I say yes, I want to be in this research?

You will be asked to perform 1 activity over the course of your program. Interactions with researchers will take place at Valencia College, School of Public Safety typically after class. The simulator session may be scheduled on a non-class day.

Cadets may volunteer to take part in the scenario, which is not part of their course. You will be asked to provide instructions to those cadets that volunteer as you would normally in police training. Following the scenario, you are asked to use a rubric to provide written feedback on the cadet's performance in the VirTra simulator, consistent with normal police training practice. As an experienced trainer, you may conduct the scenario and feedback session as you wish. The total duration of the scenario and feedback sessions is expected to be 20 minutes for each cadet.

You may also provide an after-action review to the cadets. The after-action review is not part of the study and has been included at the request of instructors to provide training to the cadets.

What happens if I say yes, but I change my mind later?

You can leave the research at any time. Withdrawing from the study will not affect your job or standing with Valencia College in any way.

Your name will not be associated with your feedback. You will not be identified beyond being an instructor at all. All of your feedback will be analyzed without reference to the name or identity of the individua. cadet or you. These de-identified data will be stored electronically on an external hard drive stored in a locked laboratory at IST for a period of at least 5 years and may be reanalyzed at either IST or ARL after completion of the study for publication purposes.

Is there any way being in this study could be bad for me? (Detailed Risks)

There are no foreseeable risks associated with the study for you.

What happens to the information collected for the research?

We will not collect any data on you. Dara collected from cadets is handled as follows.

We cannot promise complete secrecy. Organizations that may inspect and copy their information include the IRB and other representatives of this organization. We will limit personal data collected in this study to people who have a need to review this information. In addition, because this research is sponsored by the U.S. Army Research Laboratory, the Army Human Research Protections Office is eligible to review the research records. Data will be secured in locked cabinets and password-protected computers at the Institute for Simulation and Training (IST) and disposed of following IRB protocol, which includes the shredding of all documents and proper deletion of electronic information. If identifiers are removed from identifiable private information that is collected during this research, that information could be used for future research studies or distributed to another investigator for future research studies without the cadet's additional informed consent.

What else do I need to know?

This research is being funded by Army Research Laboratory

Signature Block for Capable Adult

Your signature documents your permission to take part in this research.

Signature of subject	Date
Printed name of subject	
Signature of person obtaining consent	Date
Printed name of person obtaining consent	

APPENDIX M:
IRB APPROVAL LETTER

UNIVERSITY OF CENTRAL FLORIDA

Institutional Review Board
FWA00000351
IRB00001138Office of Research
12201 Research Parkway
Orlando, FL 32826-3246

APPROVAL

October 23, 2019

Dear Samantha Napier:

On 10/16/2019, the IRB reviewed the following submission:

Type of Review:	Initial Study
Title:	A breathing intervention to enhance cardiac regulation and mitigate stress in police cadets
Investigator:	Samantha Napier
IRB ID:	STUDY00000833
Funding:	Name: US Army Research Laboratory
Review Category:	Expedited Category 4,5,6,and 7
Risk Level:	Minimal Risk
Grant ID:	
IND, IDE, or HDE:	None
Documents Reviewed:	• irb_HRP-251-FORM-FacultyAdvisorReview_v-2-12-19 (1).pdf, Category: Faculty Research Approval; • anxious thought inventory, Category: Survey / Questionnaire; • consent instructor oct 11, Category: Consent Form; • Control Consent oct 2, Category: Consent Form; • debriefing statement oct 9, Category: Debriefing Form; • demographics aug 20.docx, Category: Other; • DSSQ3 Aug 20.docx, Category: Survey / Questionnaire; • experimental consent oct 9, Category: Consent Form; • grit aug 20.docx, Category: Survey / Questionnaire; • Hardiness scale aug 20.docx, Category: Survey / Questionnaire; • NASA TLX.docx, Category: Survey / Questionnaire; • oct 11, Category: IRB Protocol; • rubric, Category: Other; • STPI aug 20.docx, Category: Survey / Questionnaire; • study orientation aug 20.ppt, Category: Recruitment Materials; • test Anxiety aug 20.docx, Category: Survey / Questionnaire;

The IRB approved the protocol on 10/16/2019.

In conducting this protocol, you are required to follow the requirements listed in the Investigator Manual (HRP-103), which can be found by navigating to the IRB Library within the IRB system.

If you have any questions, please contact the UCF IRB at 407-823-2901 or irb@ucf.edu. Please include your project title and IRB number in all correspondence with this office.

Sincerely,

Gillian Bernal
Designated Reviewer

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