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Autonomic and Behavioral Reactivity to an Acute Laboratory Stressor

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Autonomic and Behavioral Reactivity to an Acute Laboratory Stressor

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Abstract

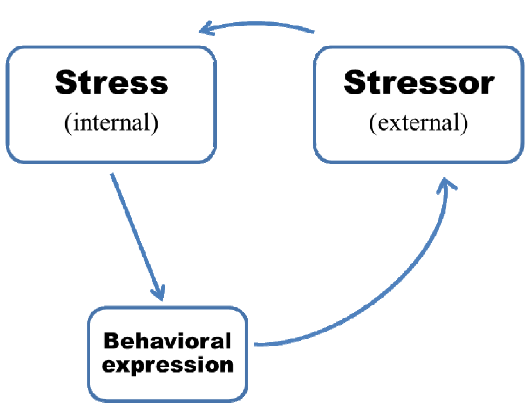
Stress has been widely shown to directly influence people's emotional and behavioral processing as well as their underlying biological systems. This project examined physiological and behavioral responses as indicators of stress and coping in the context of a psychosocial stressor in a controlled laboratory setting. We examined the association between indicators of behavioral coping and underlying physiological reactivity within participants while experiencing stress. Participants included 68 emerging adults. Physiological measures include autonomic biomarkers (e.g., heart-rate, skin conductance) at rest and during the stressor while behavioral indicators that were coded include acute verbal and non-verbal actions exhibited by participants during the stressor. Results supported the efficacy of a modified social stressor at eliciting stress responding in participants. In addition, behavioral coping was found to be associated with autonomic responding to the stressor. Exploring these associations has important implications for understanding the interaction between biological and behavioral responding to stress.

Keywords: stress; acute stressor; autonomic; behavior; coping; TSST

Introduction

The general intention of this thesis is to explore how exposure to an acute laboratory stressor affects changes in an individual's physiology and behavior. Doing so will directly explore a basic tenet of behavioral endocrinology: that hormone-behavior associations are apparent and important. The introduction will review the literature exploring the history, constructs, and processes related to stress; the anatomical and physiological components involved in stress responsivity; how one elicits a physiological stress response in a laboratory setting; and finally, the behavioral expression that can occur in response to stress exposure via observation of stress-related behaviors or coping behaviors. While many studies have previously examined physiological and psychological effects of stress in a variety of settings, few have attempted to uncover an association between specific coping behaviors and immediate autonomic functioning within the context of an acute psychosocial stressor in a laboratory setting. As such, this is the overarching goal of the present study with the addition of examining how subtle changes to experimental protocol can affect the salience and responder-rates of a laboratory stressor. The concepts outlined in the following sections may be considered in the context of the associations presented in Figure 1.

Figure 1. A theoretical construct of stress exposure and responding.



What is Stress and how is it defined?

Stress is a word that is commonly used in everyday speech to convey a very broad and vague sense of something bad or difficult happening to someone. It is used to describe the internal feeling that one has when confronting a challenging situation and is also used when referring to the situation itself (e.g., “I’m under a lot of stress right now at work.”). This sort of indistinction in usage fails to discriminate stress as either a cause or an effect. People also sometimes use stress as a catch-all term to convey ambiguous negative emotional states with vastly varying degrees of severity or is used interchangeably with negative emotional states such as fear or anxiety. Due to its varied and sometimes contradictory usage, defining and operationalizing the word itself is an essential first step to take when exploring stress.

Walter Cannon (1926) defined and popularized the notion of homeostasis, the process of maintaining a stable and constant internal state inside the body early in the 20th century. Building off this notion, the original definition of stress was actually focused on physiology rather than negative affect or subjective introspection. Hans Selye, a pioneer of early stress research, coined stress as “the nonspecific response of the body to any demand made upon it” (Selye, 1973). Selye describes general environmental changes and challenges initiating a physiological response inside the body to allow it to adapt. Selye (1936, 1973) outlined three stages of what he referred to as General Adaptation Syndrome (GAS) to describe what he identified as components of a prolonged stress response: (1) the alarm reaction, during which the body initially responds; (2) the stage of resistance, during which the response is maintained; and (3) the stage of exhaustion, during which resources have been exhausted and the response must end. Selye laid the groundwork for investigating the specific components of the stress response, emphasizing at the outset the physiology of stress. Though these stages may seem overly broad when considering stress in the context of modern biology, they provide a framework for drawing parallels with more concrete physiological systems that will be explored in the thesis.

Selye's stages of the GAS helped to provide theory and direction for currently researched mechanisms and pathways that comprise the stress response. The alarm reaction and the stage of resistance represent the initiation and maintenance of a change in bodily processes that work towards maintain a relatively homeostatic internal environment. The third and final stage is the stage of exhaustion which is entered into after sufficient duration of exposure to the stressful stimuli. Selye believed that the body's resources, or "adaptation energy", involved in maintaining this stress response state (and by extension striving to maintain homeostasis) were finite and that during the stage of exhaustion, the body was no longer able to maintain the resistance state. However, he readily recognized a lack of understanding of what precisely is lost in the transition between the resistance and exhaustion phases and that the reason was not related to insufficient caloric energy (Selye, 1973). Progressing past an explanation of this change with the unsubstantiated "adaptation energy", researchers have posited a concept involving a change in set-point of responding, called allostasis, as opposed to mere depletion of a physical resource. While homeostasis implies a fixed set-point, allostasis similarly refers to an organism's ability to achieve stability through physiological or behavioral change but further emphasizes the necessary recalibration of these set-points (McEwen, 1998; Sterling & Eyer, 1988). Understanding of this evolution of terminology in the literature can be helpful in understanding the current usage and operationalizing of these interrelated but distinct terms such as stress and stressor.

Stress definitions

While the common usage of stress may refer to external causes, internal reactions, or both, it is especially important to delineate these differing events in scientific discourse. In research throughout the 20th century, Selye and others started using "stress" to describe the internal effects that resulted from external situational variables. This distinction necessitates terminology for the causal variables, and researchers began using the term "stressor" to signify them. A component of stress that will be discussed further in later paragraphs is the "stress response" which refers to the physiological activation of specific autonomic and endocrine systems. Another importation consideration is that of the timecourse of stress which is typically delineated using the terms acute stress, referring to short-term effects after an acute stressor, and chronic stress which is characterized by repeated exposure to acute stressors or negative experiences over a longer period.

Perceived vs. Objective Stress

Stressors are deemed empirically valid when they can consistently illicit a biological stress response (Dickerson & Kemeny, 2004; Kemeny, 2003). However, this physiological effect's occurrence is contingent upon one's psychological perception, or cognitive appraisal, of the stressor (Epel, McEwen, & Ickovics, 1998; Lazarus, 1966). This essential cognitive component of stress is explained and explored through the scientific construct of *perceived stress* (aka psychological stress; Cohen, 1983) and is distinguished from *objective stress* (e.g., physiological stress). Differences in psychological reactions such as negative emotional responding (e.g., fear) or coping styles and behaviors can significantly magnify or buffer responding at the physiological level as well as the continued reappraisal and coping in response to awareness of these physiological changes. While positive coping behaviors and emotional responding can result in a buffered or shortened experience of stress, negative emotionality and destructive coping can amplify or prolong stress effects (Lazarus, 1993). An example of this continued amplification of stress by cognitive and behavioral responses can be seen in psychological disorders that involve negative affect such as major depressive disorders and anxiety disorders: individuals with these disorders tend to have exaggerated or prolonged physiological responding to stressful stimuli and rumination compared to normal populations (Boyce & Ellis, 2005; Hammen, 1991). Though it may seem logical that perceived stress and physiological stress would be associated, mixed findings have shown that the association is not always found (e.g., Callister, Suwarno, & Seals, 1992; Eck, Berkhof, Nicolson, & Sulon, 1996; Pruessner, Hellhammer, & Kirschbaum, 1999). In sum, both perceived and objective stress are important to consider when studying stress because both psychological and physiological stress are intertwined and inseparable, especially in the context of human populations. In the current thesis, we consider the interplay of these factors but focus primarily on objective stress observed in the context of an empirically valid laboratory stressor.

Physiological Components of the Stress Response System

The present study's focus on objective stress is realized through measurement of common biomarkers of the stress response system (SRS). The stress response system refers to the physiological pathways and functions involved in adaptively responding to stressful situations. The SRS is comprised of three distinct neurochemical pathways including the two Autonomic Nervous System (ANS) branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), as well as the hypothalamic-pituitary-adrenal axis (HPA). Though somewhat diverse in the scope of their functioning, the common eliciting factor of stress and the integrative connections between these systems allow for their organization into a single inclusive system (Boyce & Ellis, 2005; Del Giudice, Ellis, & Shirtcliff, 2011; Ellis, Jackson, & Boyce, 2006). The branches of the SRS are deactivated or activated hierarchically in response to stress with the PNS responding first, then the SNS, and lastly if the duration of the stressor is long enough, the HPA axis. In the review below, we focus on the autonomic nervous system as the timecourse for autonomic stress responsivity is on the order of seconds whereas peak HPA responsivity is typically not observed until 15-min after a stressor, long after behavioral stress indicators have likely terminated (Dickerson & Kemeny, 2004). To understand how the ANS can respond so quickly to a stressor requires an understanding of its organization and function.

Autonomic Nervous System: Organization and Function

Autonomic vs. Somatic Frequently, the autonomic nervous system is described as being primarily involuntary (unconsciously controlled). This is meant to distinguish the ANS from the somatic branch which is associated with voluntary control through direct connections of the brain and spinal cord to muscles and organs in the rest of the body. Somatic neurons are anatomically distinct from ANS neurons in that somatic cell bodies are in the central nervous system and directly innervate their target tissue. This direct, centrally-controlled connection allows the somatic system to be responsible for controlling voluntary movement of skeletal muscles.

Conversely, ANS neuronal pathways are composed of specialized neurons which have cell bodies within the brain or spinal cord but which terminate outside of the central nervous system and on target tissues. These neuronal pathways allow the ANS to be responsible for regulating involuntary visceral functions such as heart rate, respiratory rate, digestion, perspiration, and sexual arousal (Berntson et al., 1994; Berntson, Sarter, & Cacioppo, 2003), receiving and providing information to the brain via the spinal cord.

Though the ANS is normally thought of as governing functions that cannot be controlled consciously, this is not always the case. One example of exhibiting a degree of conscious control over autonomic function is through the use of biofeedback, a treatment intervention employed in a variety of stress-related psychopathologies, in which people use information (feedback) about their own ANS functioning to learn to manipulate certain physiological parameters usually with the goal of inducing a relaxation response and inhibiting an SNS response (e.g., increasing heart rate variability, PNS activation, Karavidas et al., 2007). The ANS is then divided into the parasympathetic and sympathetic branches which are distinct from each other in both form (neurochemical pathways) and function (effect on target tissue).

PNS vs. SNS Anatomically, the PNS is differentiated from the SNS in that PNS nerve cells are more distal from the spinal cord and closer to the target tissue, whereas SNS nerve cells are located proximal to the spinal cord in parallel nerve fibers called the sympathetic trunk. Whereas the SNS relies on acetylcholine initially in the chemical pathway and later peripheral epinephrine and norepinephrine release, the PNS largely exerts physiological control directly through the vagus nerve which descends from the nucleus ambiguus to act as an inhibitor or brake on SNS activation.

From a functional perspective, the PNS as responsible for "rest and digest" functions such as stimulating components of digestion, relaxation, and social engagement or for inhibiting more active processes such as heart rate and respiration rate. Conversely, the sympathetic branch is responsible for activating arousal mechanisms that engage the body for anticipated action. For example, sympathetic activation is responsible for physiological changes such as increasing heart rate, increasing respiration rate, dilating pupils, etc. (Berntson et al., 2003; Berntson et al., 1994).

Parasympathetic withdrawal is the first line of activation in the SRS (Porges, 2007, 2009). Other than initiating or maintaining a resting state, certain freezing-type defensive behaviors are also associated with activation of the PNS but through a differing pathway from the dorsal vagus nerve (as opposed to the ventral vagus nerve) that descends from the dorsal motor nucleus and is thought to be a more primitive pathway (Porges, 2009; Porges et al., 2007). If the challenge still persists after PNS withdrawal, the SNS will activate via nerves descending from the locus coeruleus. SNS activation occurs through the direct adrenergic innervation of target organs as well as through a slower hormonal pathway that innervates the adrenal medulla (called the sympathic-adrenal-medullary pathway, see Goldstein, 2010) which subsequently releases epinephrine and norepinephrine into the bloodstream. If the stressor or challenge still persists after SNS activation, the HPA axis will be activated resulting in the release of glucocorticoids in the bloodstream.

During ANS responses to a challenge, typically PNS and SNS responding will be conversely associated with one another through "reciprocal activation" (Berntson, Cacioppo, & Quigley, 1991). However, not all target tissues are dually innervated and functions are not necessarily always opposing (e.g., both PNS and SNS activation can stimulate salivation). Furthermore, certain conditions and functions can require coactivation of both branches such as male erection and ejaculation (Berntson et al., 2003). A recent study also found coactivation of the PNS and SNS in participants during the extreme real-world challenge of skydiving (Allison et al., 2012). Nevertheless, a typical ANS response to most stressors will involve reciprocal control.

Selection of ANS Measures

There are no direct, noninvasive measures of ANS functioning, but there are well-validated noninvasive measures which provide indirect information about activity of the SNS and PNS. Multiple indices of different branches of the ANS were selected as measures in the present study in order to provide a more complete picture of what is happening to the participant's physiology during the stressor as well as at rest. All measures used are non-invasive and include heart rate (HR), respiratory sinus arrhythmia (RSA), pre-ejection period (PEP), and galvanic skin conductance (GSC).

<u>Heart rate</u> is the number of times the ventricles contract within a minute (i.e., when using beats-per-minute metric, bpm). Due to its simplicity and availability, HR is frequently used in studies by itself or with other measures to infer changes in ANS reactivity (Allison et al., 2012; Bush, Alkon, Obradović, Stamperdahl, & Thomas Boyce, 2011; Kirschbaum, 2004; B. M. Kudielka, Schommer, Hellhammer, & Kirschbaum, 2004). The HR response has large clinical implications, as HR response has been associated with self-reported anxiety symptoms in children (Weems, Zakem, Costa, Cannon, & Watts, 2005) or is elevated at resting levels in children with separation anxiety disorder, whereas children with conduct disorder had lower resting heart rates compared to normal subjects (Rogeness, Cepeda, Macedo, Fisher, & Harris, 1990). Lowered resting HR and blunted HR responding to stressors is strongly linked with antisocial behavior in children and adolescents (Ortiz & Raine, 2004).

Changes in heart rate can be due to either PNS or SNS influences. If heart rate increases, it is difficult to disentangle whether PNS withdrawal or SNS activation is more responsible for causing the change. Because of this challenge, more specific indirect measures of sympathetic activity are often advocated for specifically measuring SNS activity in relative isolation (Newlin & Levenson, 1979).

PEP refers to the time period from ventricular depolarization to the opening of the aortic valve. PEP has been shown to be a selective index of SNS activation, especially as compared to heart rate. Decreases in PEP intervals reflect SNS activation while increases imply SNS inhibition (Berntson, Lozano, Chen, & Cacioppo, 2004; Bush et al., 2011; Newlin & Levenson, 1979). PEP is frequently used in combination with other ANS measures to establish patterns of ANS reactivity that can, for instance, help to distinguish children with internalizing and externalizing symptoms and those without symptoms (W. T. Boyce et al., 2001). In this particular study, internalizers showed higher parasympathetic reactivity compared to low-symptom children while externalizers showed lower reactivity in both branches compared to low-symptom children. Here PEP helps to establish the levels of sympathetic activation in response to laboratory stressors and when paired with other SNS indices such as HR increase and PNS indices such as RSA creates a more complete picture of ANS activity.

GSC, also known as galvanic skin response (GSR) or simply skin conductance, is a method used for measuring the electrical conductance of the skin which varies depending on the amount of moisture on the skin. Because the SNS controls the sweat glands on the skin, GSC is used as an indirect measure of sympathetic arousal (Fowles et al., 1981). When one is aroused or stressed, sympathetic arousal causes the hands to sweat and this sweat, in turn will cause their skin conductance to increase when this moisture decreases the resistance of the electrical current going through the skin via the attached electrodes. As with other sympathetic indices, blunted GSC responding (to stressors) has been demonstrated in populations with externalizing problems

(Herpertz et al., 2003) and antisocial personality disorder (Raine, Lencz, Bihrle, LaCasse, & Colletti, 2000)

RSA refers to a naturally occurring physiological phenomenon where heart rate varies as a function of the respiratory cycle. It is a valid index of heart-rate variability (HRV) which has been frequently studied throughout the physiological and psychophysiological literature. Specifically, RSA is the increasing of HR (shortened inter-beat intervals) during inspiration and decreasing of HR (prolonged inter-beat intervals) during expiration (Berntson et al., 1997; Berntson, Cacioppo, & Quigley, 1993). RSA has been shown to be an index of cardiac vagal tone and therefore a reliable indicator of PNS activation. That is, increases in RSA indicate PNS control while decreases signify withdrawal (Porges, 2009). In children, higher RSA responding (increased PNS control) during a social challenge has been linked to fewer internalizing and externalizing problems and better self-regulation behavior (Hastings et al., 2008). Also, clinical depression has been associated with lowered resting RSV (e.g., Carney, Freedland, & Veith, 2005)

In sum, non-invasive measures of sympathetic and parasympathetic activity have advantages in that they are validated and informative for understanding behavior. There are disadvantages, however, in that no single method captures purely SNS or PNS activation alone or perfectly. Nonetheless, by examining all four measures, a more complete picture of ANS activation should be viewed. It is anticipated that SRS activity to stress will be reflected in HR increases that indicate, broadly SNS activation and PNS inhibition, PEP decreases and GSC decreases to indicate SNS activation, and RSA decreases to indicate PNS inhibition.

How and Why Do We Stress People in a Laboratory Setting?

Employing experimental manipulation and control is an essential part to conducting most psychological research and furthermore any empirical scientific research. Experimental paradigms allow for explaining variability between randomly-assigned groups and allow scientists to make stronger inferences that observed changes are causatively due to the experimental paradigm rather than correlational statistical evidence. Because of these primary tennets of empirical research, the need and justification for controlled laboratory stressors is evident as a foundational feature of stress-related biopsychological research. Laboratory stressors are by nature confined to limited, specific periods of time, rendering them acute stressors that evoke finite observable periods of physiological reactivity. A laboratory stressor is generally considered to be reliable and valid if it consistently elicits a SRS response based on the physiological measures that are being observed (e.g., cortisol reactivity, cardiac reactivity, etc.). In order to accomplish this, laboratory stressors will typically include tasks or challenges that either cause physical pain or distress or evoke psychological distress. Previously used physical stressors include using electric shocks or the cold pressor task which involves submerging one's hand in ice water for a specific duration (see Walsh, Schoenfeld, Ramamurthy, & Hoffman, 1989). However, because of the current study's aim to examine psychological stress (as opposed to stress confounded by physical pain), physical stressors are not used. Due to the importance of cognitive appraisal and information filtering in the SRS in humans (Del Giudice, Ellis, & Shirtcliff, 2011), a focus on psychosocial stressors is of particular importance to the translatability of laboratory findings to real-world environmental reactivity and this type of stressor will be the focus of this study. In past research, psychosocial laboratory stressors that illicit ANS responding typically consist of completing a challenging, socially evaluated task such giving public speeches (e.g., Bassett, Marshall, & Spillane, 1987) or doing mental arithmetic (e.g., Jørgensen et al., 1990). Another example of a social stressor protocol that has been used in previous research is the Social Competence Interview (SCI), which uses a 10 minute interview-style task and has been shown to reliably activate the SNS (C. K. Ewart & Kolodner, 1991). Beyond the obvious component of something that is challenging and able to be cognitively appraised, it is important to examine some of the other mechanisms within these stressors that affect or enhance stress responding.

Some studies have demonstrated the significance of modifying social evaluative threat (SET, i.e., a situation where a person's appearance, personality, or behavior could be judged by others) in initiating a stress response in a controlled setting. SET entails challenges to people's inherent goal of social self-preservation which includes maintaining one's own social acceptance and status (Dickerson & Kemeny, 2004; Dickerson, Mycek, & Zaldivar, 2008). Increases to SET have been shown to be important in the process of eliciting specific emotional and physiological changes such as activating the SRS. For instance, the standard Trier Social Stress Test (TSST) typically calls for two confederates, but has been shown to be more reliable across individuals at eliciting stress responses with four confederates (Bosch et al., 2009) but less effective with 1-2 confederates and ineffective when the confederate(s) are present but only passively evaluating the participant (Bouma, Riese, Ormel, Verhulst, & Oldehinkel, 2009; Dickerson et al., 2008). The confederates expressing more negative commentary about the speech has also been shown to increase responding. As such, the negative evaluation component in addition to the salience and number of evaluators have all been demonstrated as essential components of SET that can increase the reliability of laboratory stressors. In addition to SET, the uncontrollability factor of a stressor has also been shown to influence rates of stress responding by modifying the length of preparatory period for a speech (Westenberg et al., 2009) or increasing self-confidence before the task (Creswell et al., 2005); both act as stress buffers and decrease rates of responding.

The aforementioned Trier Social Stress Test (TSST) is a psychosocial laboratory stressor protocol that has been used frequently in recent stress research (Kirschbaum, Pirke, & Hellhammer, 1993). The protocol entails a 10 minute anticipatory period followed by a 10 minute task period during which the participant must give a speech and perform mental arithmetic. It has been widely demonstrated as one of the only reliable laboratory protocols for activating the HPA axis due to its integration of elements of unpredictability, uncontrollability, and social evaluative threat (Dickerson & Kemeny, 2004). As SNS responding tends to precede HPA responding, with respect to the faster acting components of the SRS, the TSST, particularly the speech component, has also been found to be a reliable activator of SNS indicators (Al'Absi et al., 1997). Studies also sometimes use a child version of the TSST (TSST-C) which uses a modified speech task and smaller numbers in the math task (Buske-Kirschbaum et al., 1997; Kudielka et al., 2004). Although research supports that the TSST is likely the most reliable social stressor in a laboratory setting at eliciting an SRS response, a large percentage of individuals (30-50%) are still not responsive in terms of HPA responding (Kirschbaum et al., 1993). Though the present project's focus is on more quickly and easily activated autonomic-level responding, it is still quite concerning in terms of raising doubts about the efficacy and reliability of an experimental protocol that one third or more of participants do not experience the anticipated physiological response. It is for this reason that certain modifications (and possible enhancements) like the ones listed in the previous paragraph have been added to the protocol in the current study (see methods for a detailed list of changes).

Behavioral Coping

While the focus of this review is on the ANS as an index of physiological stress responsivity which is initiated within seconds of a stressor, this involuntary response is not the only early indicator of stress exposure. A stressor is first appraised centrally within the brain through activation of limbic and paralimbic neural circuitry (Shirtcliff et al., 2009). Within seconds, regulatory or inhibitory structures are activated and largely determine whether a stress response will be initiated peripherally within the ANS and HPA (Kern et al., 2008; Pruessner et al., 2010). Thus, the second focus of this review is on behavioral indicators of stress. Presumably, these are controlled by the somatic neurons described above and an individual can be consciously aware of behavioral or physical manifestations of this stressor. While the current study was designed to discover whether there are behavioral indicators of a stress response that can be observed within an acute laboratory setting, the relevant literature largely describes these behaviors as "coping". Even when viewed as coping, however, it is implied that a stressor has been perceived. Like the central regulation of the SRS, it is difficult to disentangle when a behavior indicates that a stressor was perceived or that coping with the stressor has been initiated.

What is Coping?

Richard Lazarus and Susan Folkman, known for their research in stress appraisal and coping; define coping (1984) as "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person." They go on to specify the importance of recognizing this definition's focus on process oriented (as opposed to trait-oriented) and situation-specific coping actions. This distinction is essential to consider for this study because the focus is on acute physiological and behavior change during a stressor rather than trait-specific styles of coping across multiple nonspecific domains or situations. In addition, though the term coping might seem to imply a beneficial or successful outcome, when researching it is important to recognize that coping effort or behavior should be looked at independently from the outcome. That is, coping is still used to refer to all efforts to manage stress regardless of whether or not they are adaptive, successful, or consistently used (Richard S. Lazarus, 1993). By using this operational definition of coping, examining behavioral responses during stressful situations as active coping efforts, rather than simply outward expression of an internal state of distress (e.g. when someone says, “He always appears very ‘stressed’ when speaking in public”), becomes possible.

How do people behaviorally cope with stress?

Throughout the literature, three types of coping strategies that are often studied include emotion-focused coping, problem-focused coping, and avoidant coping (Endler & Parker, 1994; Lazarus & Folkman, 1984). Emotion-focused coping refers to both inward and outward emotional regulation and expression, usually with the goal of managing perceived distress. It logically follows that the expression of inward emotion-oriented coping tends to reflect internalizing states such as anxiety while outward emotion-focused indicates externalizing emotional states such as anger or aggression. Problem-focused strategies describe behaviors or efforts with the intention of actively relieving or changing a stressful situation. Avoidant coping refers to one either actively or passively isolating or distancing him or herself from the stressful conditions (Endler & Parker, 1994)

These types of coping and the different strategies used are not necessarily consistent across different stressful encounters. For example, some strategies, such as positive reappraisal (focusing on positive aspects of the situation), have been shown to be somewhat consistent over time while others, such as seeking social support, are very inconsistent (Lazarus, 1993).

However, how one appraises the controllability of a stressful situation has been shown to consistently influence the coping style employed. Specifically, emotion-focused coping is the common type of coping in response to conditions that are perceived as uncontrollable while problem-focused coping is usually used in response to conditions that are perceived as controllable (Lazarus, 1993; Lazarus & Folkman, 1987); both of these styles are shown to be adaptive depending on the specific circumstances. However, clinical populations sometimes demonstrate differing trends. One study with a sample of patients with major depressive disorder found that emotion-oriented coping was associated with higher neuroticism and depression whereas problem-focused strategies were associated with less of both (McWilliams, Cox, & Enns, 2003). Research also suggests that emotion-oriented coping styles may be predictive of many psychological distress-related factors in non-clinical populations including aggressive behavior, negative self-views, anxiety, etc. (Endler, 2003). In addition, avoidant coping has been linked to increased PTSD severity (Bryant & Harvey, 1995; Johnsen, Eid, Laberg, & Thayer, 2002).

Observational measures

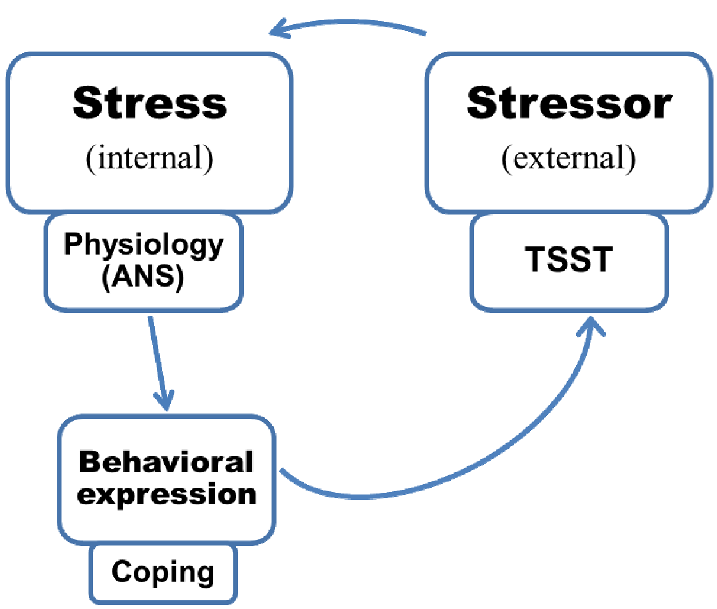
As psychology is concerned with the study of behavior, observational measures of identifying and distinguishing specific behaviors have been used extensively used in this field historically. Observational behavioral coding systems have been used frequently in psychological research on animals as well as humans. Founders of psychological behaviorism theories such as John Watson were some of the first to employ systematized observation of controlled experiments with both animals and humans (e.g., Watson & Rayner, 1920). A growing interest in non-verbal behaviors and their emotional and physiological significance in the 1960's and 70's spurned the creation of non-verbal coding systems such as the Facial Action Coding System (FACS, Ekman & Friesen, 1978) which evaluates facial expressions for their emotional significance. One example that is more specific to the current context of an acute psychosocial stressor is the Social Competence Interview (Ewart & Kolodner, 1991), an interview-style social stressor similar to the TSST that employs a validated auditory coding scheme (using recorded audio) to evaluate interpersonal skills, problem-focused coping, and social impact (Ewart, Jorgensen, Suchday, Chen, & Matthews, 2002).

Although self-report measures are useful and very easy to employ in research, Lazarus (1993, 1987) and others have expressed the importance of using observational measures as well in order to reduce self-reported bias and increase objectivity. While self-report measures are useful in identifying trait-related styles of coping in general, they are not useful for reflecting immediate coping behaviors in the acute context of a laboratory stressor. Because identifying these more immediate coping behaviors was one goal of the present study and because videos of the TSST participants were readily available, observational coding was used to reflect these behaviors. The coding scheme was adapted from a previous study (Marceau, Zahn-Waxler, Shirtcliff, Schreiber, & Klimes-Dougan, under review) that used the domains of the Coping Inventory for Stressful Situations (CISS; Endler & Parker, 1990) that were mentioned above as categories for coping behaviors to be coded. Marceau et al. (under review) found that certain behaviors in an acute setting map onto the trait-based coping tendencies that the domains reflect. This is important for the current project because many of the commonly used coping behaviors in self-report items such as thee CISS reflect real-world situations and are not likely to be observed in the context of a controlled laboratory setting (e.g., "I distract myself by watching a movie or going shopping). In this setting, more context-appropriate behaviors must be used to reflect, for example, avoidance-oriented coping such as looking away or down during a speech task.

Though these concepts of physiological reactivity and behavioral coping may seem divergent, the common context of stress connects them together well. Previous research has supported associations similar to those outlined previously in Figure 1. For example, coping style has been linked to autonomic functioning. Ramaekers et al. (1998) found that active coping was associated with less global autonomic activity in a non-clinical sample. This follows with previous research linking PTSD and anxiety-related dysfunction to elevated levels of baseline autonomic arousal (e.g., Rogeness et al., 1990). Beyond the more generalized trait-based coping styles which are indicative of behavior in general, specific acute behaviors have also been linked to autonomic functioning. For example, studies have found that both voluntary and involuntary facial expressions can be linked to emotion-specific autonomic activity (Ekman, Levenson, & Friesen, 1983; Levenson, Ekman, & Friesen, 1990). More specifically integrating acute coping processes and autonomic functioning, the association of emotion-oriented coping and frequency of experienced state anxiety (Dusenburg & Albee, 1988; Endler & Parker, 1990) and state anxiety's association with increased sympathetic arousal (e.g., Endler & Parker, 1990) is one example of how coping is indirectly linked to autonomic functioning through behavior (see Figure 2).

In addition to the previous research explored throughout this introduction, these findings illustrate the importance of examining stress, autonomic functioning and reactivity, and coping styles and behaviors in a variety of settings. While the literature does have research that examines the relationship between trait-based coping styles and behavioral and autonomic functioning, much less is known about coping behaviors in an acute setting and even less about their relationship with autonomic reactivity during an acute stressor. Though it might seem like an obvious relationship to investigate, it really is quite surprising that more is not known about this association between behavior and biological underpinnings in an acute setting considering the fact that it is such a basic tenet of biological psychology. In addition, given that the face validity of a proposed psychosocial is contingent upon some sort of behavioral or physiological stress response, examining these outcomes is also important from a methodological standpoint for further validation of the stressor. Because of this gap in the current literature, this thesis aims to examine the relationship between coping behaviors and autonomic arousal (reactivity) in the context of an acute laboratory stressor.

Figure 2. A theoretical construct of stress exposure and the resulting physiological responding, behavioral expression, and coping.



Present Study

Aims of the present study include exploring the relationship between ANS responding and coping behaviors during a social stress task in a laboratory. Beyond a methodological point to examine how people behaviorally cope during an acute laboratory stressor, specific hypotheses include:

1. **Participants' autonomic nervous systems will respond to our enhanced version of the Trier Social Stress Test.** Compared to baseline levels, we predict that during the stressor task participants' PEP will decrease (SNS activation), RSA will decrease (PNS withdrawal), HR will increase (SNS activation and PNS withdrawal), and GSC will increase (SNS activation).
2. **Coded behaviors will be indicative of coping in an acute setting.** We predict that three to five coping factors will emerge from a factor analysis of the coded acute behaviors that reflect different domains of coping. A more detailed, though somewhat speculative (due to lack of prior research) prediction of which specific behaviors might load together is included below (under Behavioral Coping portion of the Method section).
3. **Stress coping behaviors exhibited during the TSST will correlate with ANS activity.** We predict that the types and frequencies of stress coping behaviors coded from videos taken during the task will correlate with the participant's autonomic activation (a) at baseline, (b) across the duration of the task, and (c) after the stressor has terminated.

Method

Participants

A total of 68 participants (34 males) were recruited from the Greater New Orleans area. Participants' ages ranged from 18-50 (*M*=24.2, *SD*=6.2). Participant ethnicities included Caucasian (43%), Hispanic (16%), Black (12%), Asian (11%) and Other (18%).

Procedure

Participants were asked to come to the laboratory from 2:00 p.m. – 4:30 p.m. on a pre-scheduled afternoon. Upon arrival, the participant was first greeted by the 'experimenter' and led to a room to be given the informed consent form which they would sign if they still agreed to participate in the study. Participants were then given water, instructed to turn off any cellphones, and the experimenter would then record height and weight measurements. The experimenter would then proceed to apply 9 electrodes to the participant's upper body and connect them to a small ambulatory monitoring device (Mindware Technologies, LTD.) which was then clipped to the participant's belt or pants. After being connected, physiological measures were collected continuously throughout the laboratory visit via wireless transmission to an unseen data acquisition computer in another room. Participants were then asked to sit and fill out a packet of questionnaires until it was time for the task. Baseline physiological data is later extracted from this rest period of 45min to 1hr.

<u>TSST</u>. Approximately 10-15 minutes before a target time of 3:00 p.m. to begin the TSST the experimenter explained to the participant that they would be giving a speech to a panel of judges who were experts at evaluating non-verbal behavior. They were told to fill the allotted 5 minutes talking about themselves and their personal characteristics and qualifications as if they were interviewing for their dream job and that it paid very well. They were told that they would

also be recorded via two video cameras. The participant was then given 10 minutes alone with a pad and pen to prepare for the speech. The participant was then asked to leave their notes and led to the interview room by the experimenter. The 3 confederates (prior trained to maintain a stern or unemotional affect) dressed in lab coats sat behind a desk while one instructed the participant to step up onto a small raised platform stage that was lit with bright spotlights and were told to begin. If the participant paused at any point during the 5 minute speech for more than 5 seconds, a confederate would prompt them by saying, “You still have time. Please continue.” After the speech portion of the task, the participant was instructed by one confederate to begin the math portion of the task by subtracting the number 13 from 6,233 and continuously from the remainder until they are told to stop. If the participant made a mistake, they were instructed to start over with the prompt. After the second 5 minutes were over, the participant was instructed to return to the other room and debriefed by the experimenter with reassurance that they were not actually being evaluated or scored based on their performance during the task but that we were interested in what was going on in their body while they were under stress. Participants were also explained that the reason for not telling them everything ahead of time was because then the situation would not have been stressful. For the remainder of the time in the lab, the participant sat comfortably and continued filling out their questionnaire packet. When the allotted time had passed, the electrodes and ambulatory unit were detached from the participant.

Compared to standard TSST protocols, several components were modified or added with the aim of increasing the salience of the stressor in this project. As outlined in the previous laboratory stressor section, social evaluative threat is of great importance. To increase SET, 3 confederates were used rather than only 2. A small elevated platform was used as a stage for the participant to stand on in addition to bright spotlights being pointed at the participants (not too bright so they couldn't clearly see the confederates). In addition, 2 cameras on tripods were clearly visible in the room and were actually recording the participant to allow for later coding of behavioral activity.

In addition, for a subset of participants, there was a modification to the script immediately after the speech task (and before the math task) including a social evaluation (e.g., "you're not performing up to our standards…") and a "disincentive" (modification 1, n=13) scenario or an "incentive" (modification 2, n=15) scenario was presented by the speaking confederate regarding the possibility to have their compensation ($10 given upon arrival) taken away (disincentive modification 1) or increased (incentive modification 2) based on performance during the math task. Though these modifications will not affect the coded behaviors for this study because they follow the speech task, the modifications should be noted because of their possible effect (probable increase) on ANS responding.

Measures

<u>Autonomic Measures</u>: Autonomic data were collected via an ambulatory electro-impedance cardiograph (Model: MW1000A; Mindware Technologies, LTD.) and streamed wirelessly via Wi-Fi to a data acquisition computer running Mindware's Biolab acquisition software. The ambulatory device included 9 electrodes with leads connecting to a modified PDA inside a specialized enclosure that could be comfortably clipped onto a participant's belt or pants with minimal restriction of mobility. Two electrocardiogram (ECG) electrodes were placed on the right clavicle and the lower left rib while four impedance cardiography (IMP) electrodes were placed on the back on the vertebra prominens (i.e., C7) and lower-middle spine and on the chest at the suprasternal notch and the xiphoid process (i.e., the top and bottom of the sternum respectively). Also, two GSC electrodes were placed about an inch apart on the palm of the

hand. Psychophysiological measures examined in the present study include heart rate (HR), respiratory sinus arrhythmia (RSA), pre-ejection period (PEP), and galvanic skin conductance (GSC; see previous sections for an explanation of ANS measures).   Similar Mindware system configurations have been used widely in studies across the psychophysiological literature (e.g., Berntson, Lozano, Chen, & Cacioppo, 2004; Boyce et al., 2001; Curtin, Lozano, & Allen, 2007; Del Giudice, Hinnant, Ellis, & El-Sheikh, 2011).

All physiological data were cleaned in 60 second intervals using Mindware analysis software programs.   ECG data were cleaned using HRV 3.0.15 to manually examine and correct or remove R-peaks of the QRS complex (which indicates ventricular depolarization) that are highlighted as possible outliers. Though the software's automatic R-peak detection algorithms worked well the majority of the time, sometimes data points would need to be manually moved or deleted if they were incorrectly placed. Data within these 60 second periods were only used for analysis if 30 seconds of continuous, viable data were present (this was not the case if an interval had excessive noise in the recorded signal). HR and RSA scores were obtained in 30 second intervals using this software. Impedance cardiograph data were similarly cleaned using IMP 3.0.15 in 60 second intervals, and PEP scores were obtained in 30 second epochs. GSC data were cleaned using EDA 3.0.9 in 60 second intervals and again scored in 30-second epochs using average electrodermal activity levels. Epoch periods of between 10-60 seconds have been used frequently throughout previous psychophysiological literature when examining ANS indices.

Baseline levels were averaged from a continuous 5-minute period before the TSST when the participant was sitting still and filling out non-emotion provoking questionnaires. Pre-stressor levels were averaged from the 5-minutes immediately preceding the TSST when the participant was preparing for the speech-task. Reactivity levels were averaged in 30-second epochs for the 10 minute duration of the TSST and again for two 5-minute intervals representing the speech and math task portions of the stressor. Finally, post-stressor levels were averaged from the 5 minutes immediately following the TSST when the participant returned to the other room to continue filling out questionnaires.

<u>Behavioral Coding</u>: The observational coding system used was designed for the present study to specifically assess coping behaviors being exhibited during the speech task of the TSST. Four coders (3 male, 1 female) completed approximately 10 hours of training Each five minute video was coded in ten 30-second epochs with a 1 (behavior occurred) or 0 (behavior didn't occur) and was viewed twice by each coder, once with the sound muted for physical behaviors and once with sound through headphones for verbal behaviors (see Appendix 1 for criteria used to determine whether or not a behavior occurred). Fourteen different behaviors were coded throughout the epochs in addition to three global ratings for each video. Inter-rater agreement estimates were computed on 20% of the videos and were generally favorable with average cohen's kappas of .78. The specific behaviors we chose to observe (see list below) were selected after preliminary examination of ~20% of the videos for behaviors exhibited during the TSST that seemed to exhibit acute emotional, anxious, or stress-related behaviors that might reflect specific coping styles as described by Endler and Parker (1994) including problem-focused, emotion-focused, and avoidant coping. While behaviors like these have been employed previously as behavioral indicators of distress or anxiety (e.g., Pollatos et al., 2011; Yim, Quas, Cahill, & Hayakawa, 2010), they have not typically been interpreted as indicators of coping. More recently, however, Marceau and colleagues (under review) observed behaviors in acute settings that reflected coping domains that helped further distinguish inward- and outward-

focused emotion coping as well as active and passive avoidant coping . Certain behaviors were included from Marceau's study that were deemed applicable and observable in the current setting (e.g., looking away, silence, etc.). Mapping our observational system to prior literature will enhance future comparison to other coping-related studies. While specific behavior groupings have been attempted below, it is important to reemphasize that these predictions are speculative due to the lack of current research that examines these types of acute behaviors in relation to coping.

Specific behaviors along with possible groupings include:

1. Problem-focused coping: (1) gestures (intentional movements of the arms or hands). Other computed variables using the lacking of avoidant behaviors will be used to add to the problem-focused category. For example, less coded silence will imply more task-focused behavior (i.e., talking continuously for the entire 5 minutes as instructed).
2. Inward-focused emotion coping: (1) smiling, (2) laughing, (3) studdering/correcting speech, (4) nervous tone of voice.
3. Outward-focused emotion coping: (1) being defiant or non-compliant, e.g., saying "no" in response to "please continue" prompt from confederate. The global rating (1-10) of aggression of tone of voice were used for outward emotion coping as well.
4. Active avoidant coping: (1) Asks irrelevant questions/says irrelevant statements, e.g., "How much time do I have left?" or "This is hard".
5. Passive avoidant coping: (1) looking away or down, (2) fidgeting/stereotypy, (3) swaying/shrugging, (4) deep breath/swallows, (5) mumbles/whispers, (6) silence, (7) excessive interjections.

Additional Measures. Although not the point of the present study, a large questionnaire packet of several self-report measures was also filled out by the participant during the experiment. Several of these items and scales may be examined in future related analyses. Examples include the CISS as an index of dispositional or trait coping styles; the HBQ to screen for health conditions that could create potential ANS confounds; the Life Events Checklist (LEC) to assess for chronic stress through past stressful life events; and the Daily Hassles (DH) questionnaire to assess for perceived stress over the last few days.

Analytic Strategy

To test whether participants' exhibited autonomic nervous system responses to the stressor, a series of Repeated Measures ANOVAs will be employed with time as the main predictor and each autonomic indicator (e.g., HR, PEP, GSC, RSA) as the outcome(s). Follow up t-tests will be used to compare levels across conditions (i.e., baseline to stressor; stressor to post-stressor; baseline to post-stressor).

A factor analysis (Principle Axis Factoring) will be conducted to test whether the coded behaviors would load together based on the type of coping strategy that was being employed (for hypothesized groupings, see "Behavioral Coding" section above). We anticipate that three to five coping behavioral factors will emerge. According to the groupings of behaviors extracted from these analyses, we will then use the factor scores to correlate these coping strategies with ANS indicators at each time (e.g., baseline, across the stressor and after the stressor) to test whether stress coping behavior strategies are associated with ANS activity.

To further explore the association between coping and ANS activation, a series of Repeated Measures Analyses of Covariance (ANCOVAs) will be employed to test for interaction effects of coping and time on ANS indicators over time. This will allow us to interpret results more specific to ANS *reactivity* over time, as opposed to the correlations which examine the ANS time-points independently from one another. Follow up RM ANCOVAs will also be used to identify how coping affected specific changes in intervals (i.e., baseline to anticipation, anticipation to speech, speech to math, and math to recovery).

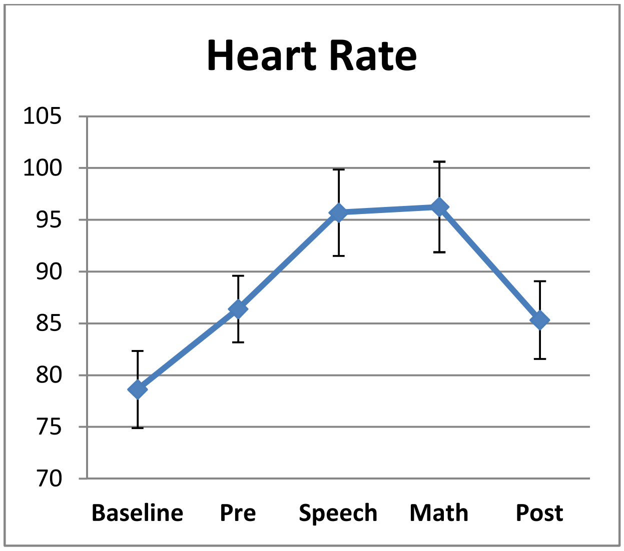
Results

Do participants show an ANS response to the stressor?

To test whether the participants in this study exhibited an autonomic response to our laboratory stressor, a series of Repeated Measures ANOVAs were conducted to see if there was a main effect of time on ANS levels (separately for HR, PEP, GSC, and RSA) across 5 time points (5 minute averages of baseline, pre-stressor, speech task, math task, post-stressor). Follow-up Paired-Samples T-tests were also used to indicate significant changes across concurrent intervals (baseline to pre-task to indicate anticipation; pre-task to speech to indicate reactivity to the speech; speech to math to indicate the second stressor component; math to post-task to indicate initial recovery from the stressor). Greenhouse-Geisser corrections were employed because sphericity could not be assumed (Mauchly's W=.508, $p<.01$) for, HR, PEP, GSC, or RSA.

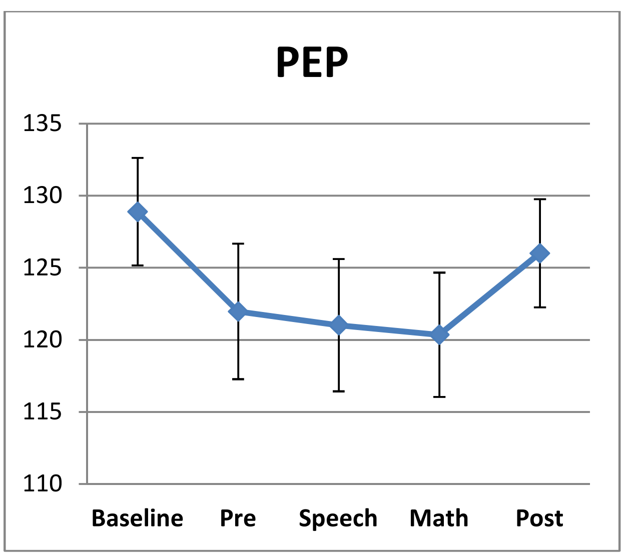
Heart Rate. Heart rate levels changed significantly across the five intervals (see Figure 3), $F(3.02, 165.88)=51.01$, $p<.001$. Specifically, HR increased significantly from baseline to pre-stress (i.e., anticipation), $t(57)=5.20$, $p<.001$, continued to increase from pre-task to speech (i.e., initial reactivity to speech), $t(57)=6.00$, $p<.001$, remained constant throughout the stressor (from speech to math), $t(56)=.59$, $p=.56$, and decreased following the stressor (i.e., recovery), $t(56)=10.35$, $p<.001$.

Figure 3. Average heart rate across time intervals



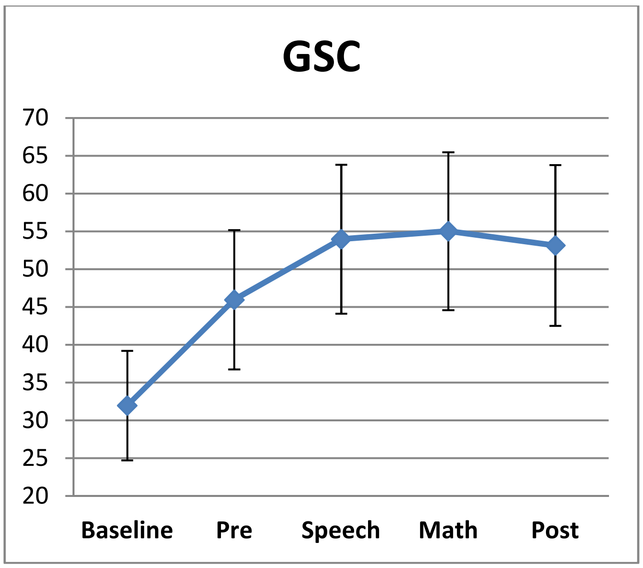
Pre-ejection Period. PEP changed significantly across the five intervals (see Figure 4), $F(3.07, 153.66)=8.45$, $p<.001$, showing an expected pattern of lower PEP during a stressor (low PEP indicates greater SNS arousal). Specifically, PEP decreased significantly from baseline to pre-task, $t(54)=4.76$, $p<.001$, did not decline significantly further during the speech, $t(54)=.90$, $p=.373$, continued to remain relatively low throughout the stressor (from speech to math), $t(52)=.43$, $p=.67$, and then increased significantly following the stressor, $t(52)=3.82$, $p<.001$.

Figure 4. Average PEP across time intervals



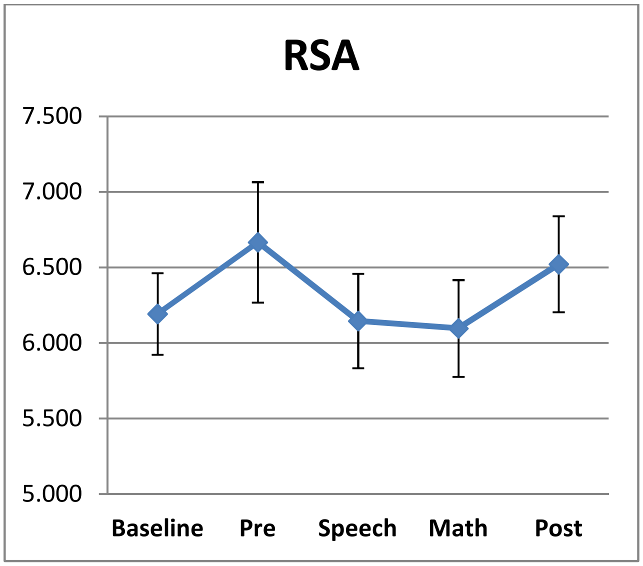
Galvanic Skin Response. GSC changed significantly across the five intervals (see Figure 5), F(1.68, 92.51)=27.97, p<.001. Specifically, GSC increased significantly from baseline to pre-task, t(57)=6.24, p<.001, continued to increase during the speech, t(56)=4.16, p<.001, remained elevated throughout the math component of the stressor, t(57)=.82, p=.41, and still remained elevated after the stressor ended (i.e., recovery), t(59)=1.34, p=.18.

Figure 5. Average GSC across time intervals



Respiratory Sinus Arrhythmia. RSA changed significantly across the five intervals (see Figure 6), F(3.01, 165.43)=5.745, p<.001. Specifically, RSA increased significantly from baseline to pre-task, t(57)=3.31, p=.002, decreased substantially during the speech, t(57)=2.76, p=.008, remained low during the second component of the stressor, t(56)=.44, p=.66, and then increased after the stressor terminated (i.e., recovery), t(56)=3.11, p=.003. It should be noted that RSA decreases indicate PNS inhibition and therefore arousal.

Figure 6. Average RSA across time intervals



Do the coded behaviors load into factors as predicted?

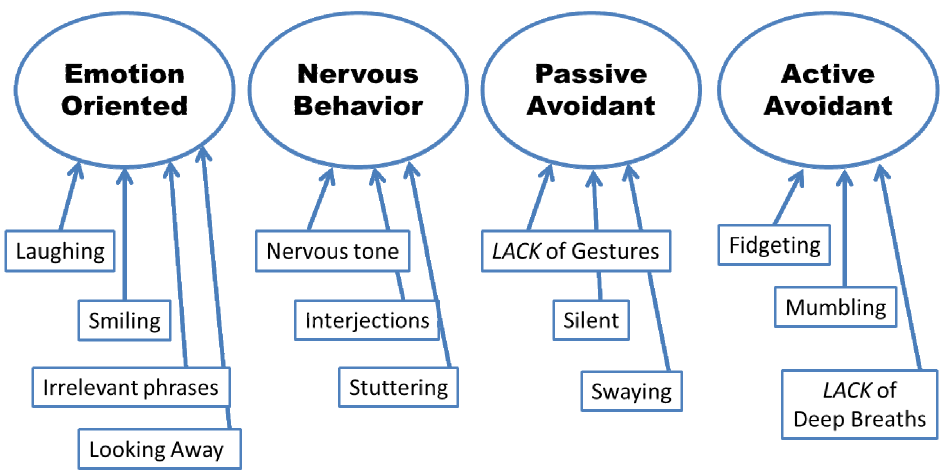
The coded acute behavior items were factor analyzed using principle components analysis with Varimax (orthogonal) rotation which was chosen for simplicity and to maximize factor loading variance. The "Defiant/Non-compliant" behavior was excluded from the analysis due to the behavior rarely occurring and the resulting skewed distribution. Because past research suggests that salient loadings tend to be above .4, coefficients below .4 were suppressed. Four factors with Eigen values over 1 were extracted (3.03, 2.23, 1.56, & 1.28) and accounted for a total of 62.3% of the variance Factors 1 and 2 seemed to be capturing emotion related behaviors with factor 1 being termed Emotion-oriented (EO) and factor 2 being more specific to outwardly nervous verbal behaviors (NB) while factors 3 and 4 seemed to be capturing passive (PA) and active avoidant (AA) behaviors respectively (see Table 1 and Figure 7). While silent and irrelevant phrases both cross loaded into Emotion-oriented coping and Passive Avoidant, their association with both factors seems to make sense logically (for further explanation, see

Discussion section). These factor scores were saved as new variables termed "coping strategies" to be used in subsequent analyses.

Table 1. Rotated Component Matrix with factor loadings

	Emotion Oriented	Nervous Behavior	Passive Avoidant	Active Avoidant
Laughing	0.836			
Smiling	0.819			
Looking Away	0.5			
Irrelevant questions or statements	0.552		0.489	
Silent	0.419		0.686	
Nervous tone		0.824		
Studdering or Correcting speech		0.676		
Interjections		0.8		
Gestures			-0.828	
Swaying or Shrugging			0.446	
Fidgetting				0.709
Mumbling				0.606
Deep Breaths				-0.606

Figure 7. Coping behavior factor loadings (stronger loadings closer to latent factors)



Are the coping strategies associated with ANS activity?

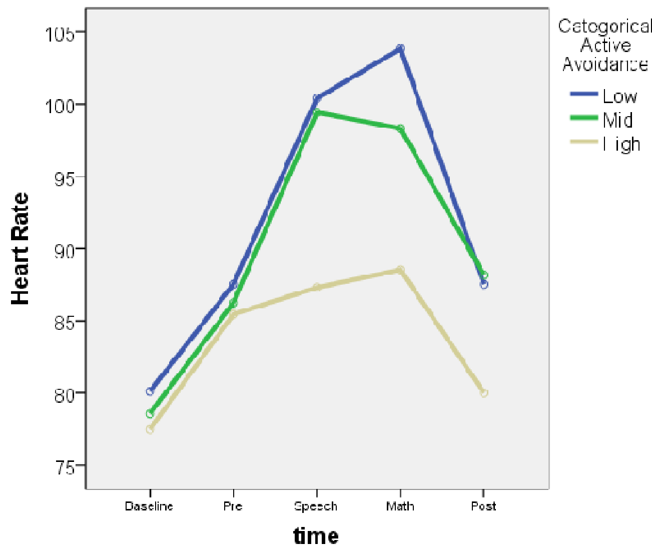
To explore the association between coping strategies and ANS activity, bivariate correlations employing Pearson's R were conducted between coping strategy scores and ANS activity levels (HR, PEP, GSC, and RSA) at each of the 5 time-points. Significant associations were found between active avoidant scores and HR during the speech task, $r(54)=-.35$, $p=.011$, as well as between active avoidant scores and HR during the math task, $r(53)=-.38$, $p=.005$. A significant association was also found between nervous behavior scores and RSA during anticipation of the stressor, $r(54)=.36$, $p=.008$. While these results indicate associations between coping and ANS levels *independently* over time conditions and are a good starting point, the following analyses more specifically explore these associations while controlling for within-individual changes in levels over time.

Does ANS reactivity vary with coping strategy scores?

To test whether ANS reactivity was associated with certain coping strategy scores, a series of 16 Repeated Measures Analyses of Covariance (ANCOVAs) were conducted with ANS levels (separately for HR, PEP, GSC, RSA) across time (baseline, pre-stressor, speech task, math task, post-stressor) included as within-subjects factors and coping strategy scores (separately for Emotion, Nervous, Passive Avoidance, and Active Avoidance coping scores) included individually as covariates. Time by coping strategy interaction effects were examined for each analysis. Within-subjects main effects of time are reported above; inclusion of the covariates does not change the prior RM ANOVA main effects of time (analyses available from author upon request). To determine which specific time intervals (e.g., baseline to anticipation) were associated with coping strategies, significant interaction effects were followed-up with RM ANCOVAs with ANS levels across 2 concurrent time points as within-subjects factors and coping strategy scores as a covariate (again looking at time*coping interaction effects). Greenhouse-Geisser corrections were again used to help offset spherecity issues (p values<.01).

Heart Rate. A significant time*Active Avoidance effect was found on heart rate $F(3.22, 160.98)=4.83$, $p=.002$, $\eta_p^2=.088$. Follow-up RM ANCOVAs indicated that high Active Avoidant coping concurrently buffered HR responding during the speech task (from pre-task to speech), $F(1, 51)=5.84$, $p=.019$, $\eta_p^2=.10$, and later from math to recovery, $F(1, 51)=5.73$, $p=.02$, $\eta_p^2=.10$. There inferential statistics we interpreted controlled for continuous coping variables while the following figures (8-11) used categorical coping variables to aid interpretation of directionality; this technique for dichotomization of variables using 3 levels and interpretation with continuous inferential statistics has been previously demonstrated and justified (MacCallum, Zhang, Preacher, & Rucker, 2002). Figure 8 illustrates this effect with a categorical coping variable of high AA scores being those who score more than .5 SD above the mean and low AA scores being those who score more than .5 SD below the mean (see Figure 8). Specifically, figure 8 shows that the low HR across time is apparent especially within those scoring highest on Active Avoidance behaviors such as fidgeting and mumbling.

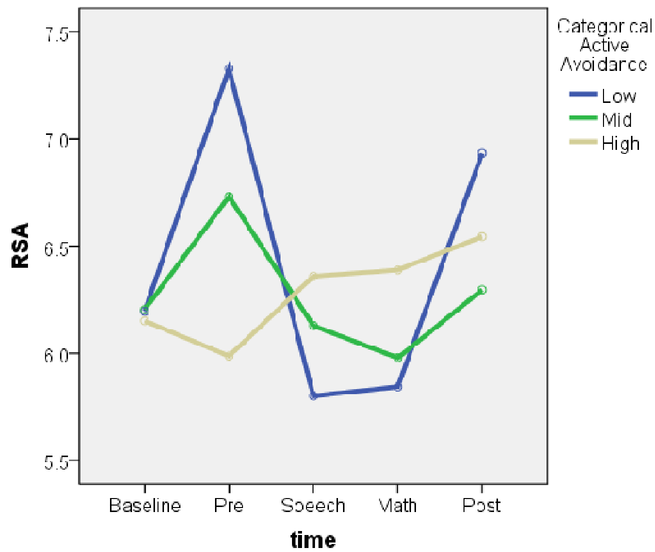
Figure 8. HR across time by levels of Active Avoidant Coping



RSA. A significant time*Active Avoidance effect was found for RSA, F(3.21, 160.32)=5.04, p=.002, η_p^2=.092. A significant interaction of time*Nervous Coping was also found for RSA, F(3.02, 150.88)=2.90, p=.037, η_p^2=.055.

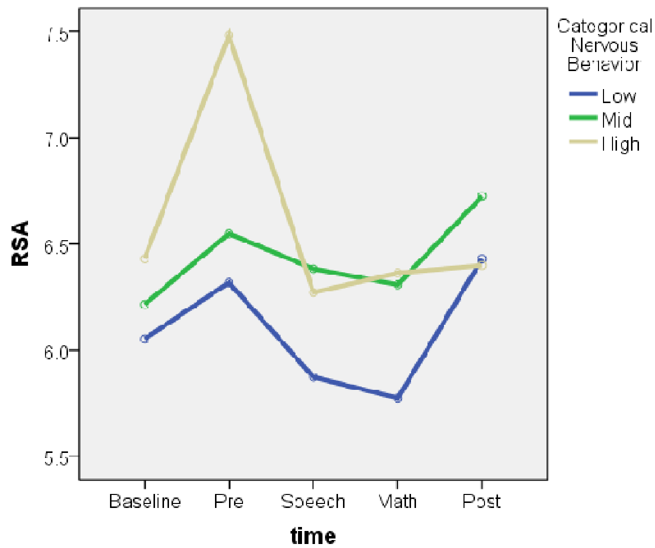
Higher Active Avoidant coping was also related to RSA reactivity patterns across the intervals. Individuals who would later score high on Active Avoidance had lower RSA (i.e., greater PNS inhibition and arousal) going into the speech from baseline to anticipation F(1, 51)=4.43, p=.04, η_p^2=.08. During the speech, however, individuals with higher Active Avoidance scores had higher RSA levels (i.e., greater PNS inhibition), F(1, 51)=9.55, p=.003, η_p^2=.16 (see Figure 9 which uses a categorical coping variable of high AA scores being those who score more than .5 SD above the mean and low AA scores being those who score more than .5 SD below the mean).

Figure 9. RSA across time by levels of Active Avoidant Coping



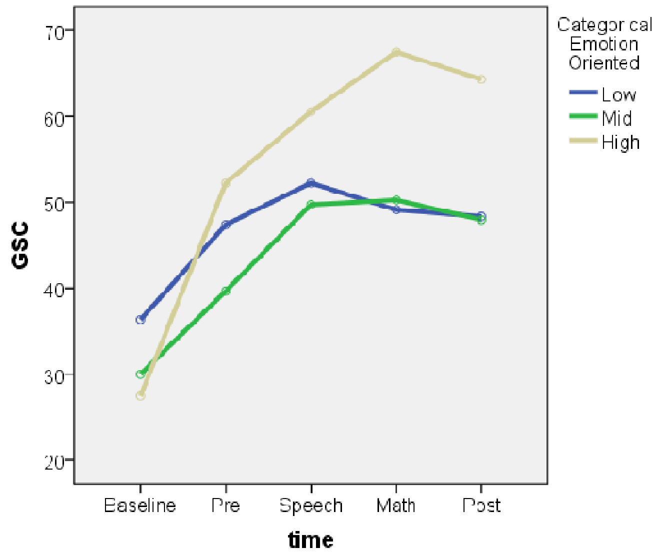
Higher Nervous coping had the inverse effects on pre-stressor intervals of RSA. Individuals who went on to display more nervous coping behavior had greater RSA (i.e., more PNS inhibition) within the time period of baseline to pre-task (i.e., anticipation), $F(1, 51)=7.48$, $p=.009$, $\eta_p^2=.13$. Individuals who had more nervous coping behaviors displayed greater RSA during the speech (i.e., from anticipation to speech), $F(1, 51)=4.06$, $p=.037$, $\eta_p^2=.08$. Figure 10 illustrates that individuals who were low on Nervous behavior were low on RSA (e.g., displayed greater PNS inhibition to support heightened ANS arousal) whereas individuals who scored high on Nervous behavior were typically high on RSA (e.g., displayed greater PNS activation or attempted to diminish overall ANS activation) (see Figure 10 which, again, uses a categorical coping variable of high NB scores being those who score more than .5 SD above the mean and low NB scores being those who score more than .5 SD below the mean).

Figure 10. RSA across time by levels of Nervous Behavior Coping



GSC. A significant time*Emotion-oriented coping interaction was found for GSC, F(1.71, 83.62)=5.13, p=.011, η_p^2=.095. Individuals who later demonstrated higher Emotion-Oriented coping were associated with heightened GSC responding during anticipation (i.e., from baseline to pre-task), F(1, 51)=4.72, p=.034, η_p^2=.09, and additional heightened responding during the math task (i.e., from speech to math), F(1, 51)=6.27, p=.016, η_p^2=.11 (see Figure 11 which, again, uses a categorical coping variable of high EO scores being those who score more than .5 SD above the mean and low EO scores being those who score more than .5 SD below the mean).

Figure 11. GSC across time by levels of Emotion Oriented Coping



Discussion

The primary purpose of this study was to examine the effects of an acute psychosocial stressor in a laboratory setting on physiological and behavioral changes and to explore how certain behaviors and indices of physiological responding are associated in such a context. We used a modified version of the TSST as the stressor and measured indices of ANS responding (HR, PEP, GSC, and RSA) as well as observed behaviors exhibited during the task that were hypothesized to reflect behavioral coping as a response to the demands of the stressor. Our hypothesis that participants' autonomic nervous systems would respond to our modified TSST was strongly supported by significant reactivity patterns over time of HR, PEP, GSC, and RSA. Our second hypothesis of observed behaviors reflecting coping was generally supported by the extraction of 4 factors that seemed to reflect different types of coping-related behavior including Emotion-Oriented (EO) coping, Nervous Behavior (NB) coping, Passive Avoidant (PA) coping, and Active Avoidant (AA) coping. Though not all behaviors loaded into factors exactly as previously predicted, factors were still found to reflect coping domains. These 4 factor scores were used to explore associations between coping strategies and ANS activity and reactivity over time. Independent associations were found between Active Avoidant (AA) coping and HR levels during the stressor and between Nervous Behavior (NB) coping and RSA during anticipation. Three of the four coping factors were also found to be associated with specific ANS indicators across time (i.e., ANS reactivity). These findings help to reiterate the importance of examining multiple measures of psychological, behavioral, and physiological change in response to acute stressors due to the fascinatingly inter-related mechanisms they reflect.

Do participants show an ANS response to the stressor?

As expected, participants demonstrated significant responses in each of the 4 indices of ANS activity to our modified TSST. Given the very quick timing of ANS responses to stress and their observed effects, the reactivity patterns of our indices are indicative of current states of physiological arousal or distress. Heart rate was shown to be elevated across anticipation, stressor, and recovery compared to baseline. Also, HR was shown to increase leading up to the stressor, remain elevated throughout the stressor, and decrease following the stressor. These changes demonstrate parasympathetic withdrawal and sympathetic activation in response to the stressor and decreases in sympathetic control immediately following the stressor. Changes in PEP indicated increased SNS activity starting during anticipation and sustained across the task with decreases in SNS activity following the stressor. Change in GSC levels also indicated an SNS response to the stressor but with increases continuing from baseline across anticipation to the stressor and only slightly decreasing following the stressor. As an index of parasympathetic control, changes in RSA demonstrated increased PNS control immediately before the stressor (compared to baseline), parasympathetic withdrawal sustained throughout the stressor, and increased parasympathetic control following the stressor.

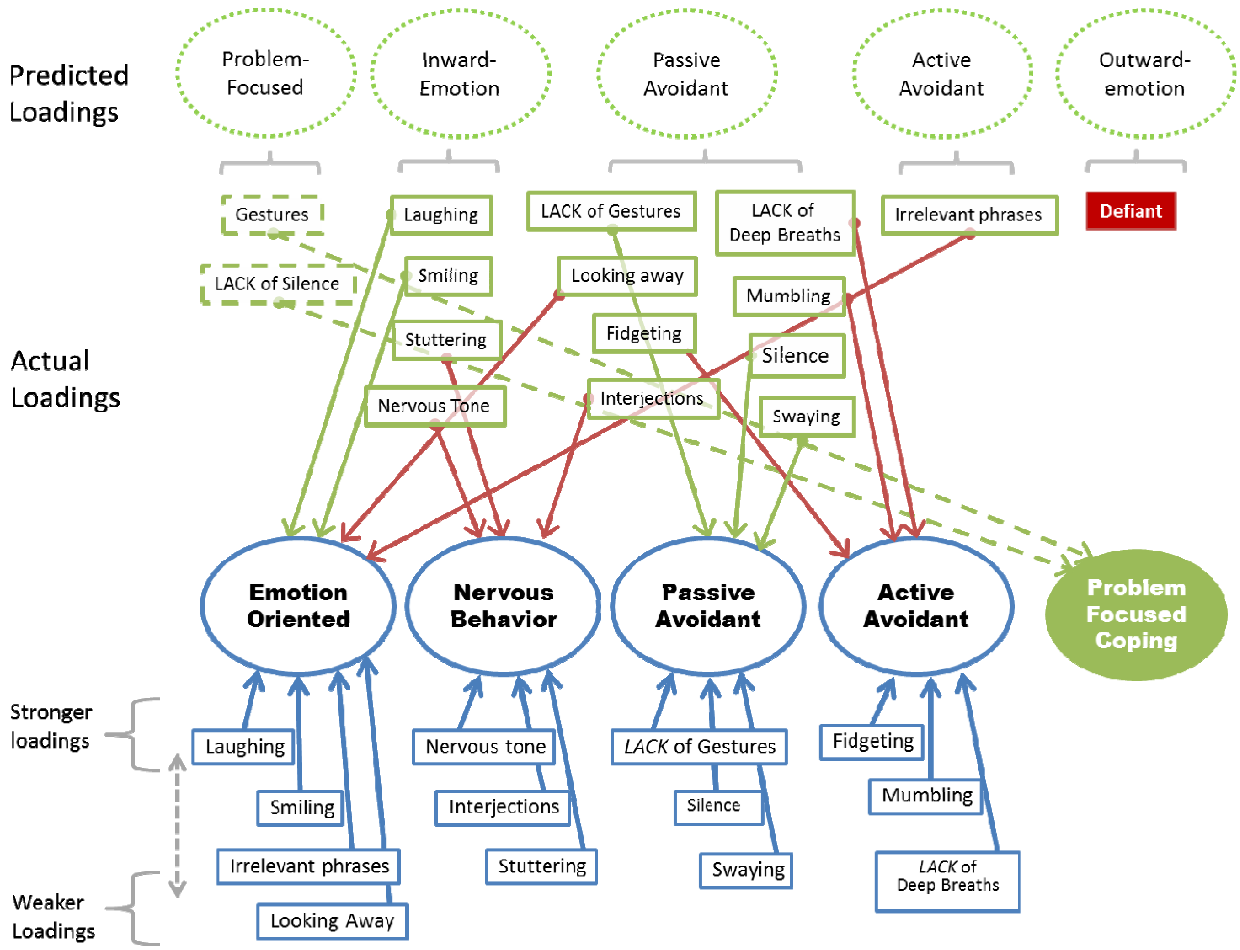
These findings are in general very consistent with past research that observed HR and other sympathetic indicators changes in response to the TSST (Al'Absi et al., 1997; B. Kudielka, et al., 2004) as well as research that examined PNS activity in response to the TSST and similar acute stressors (Bush et al., 2011; Cacioppo, Uchino, & Berntson, 1994). Because PEP is more specific to SNS activation than HR, the steady levels (lack of further decrease) from anticipation to speech are perhaps an indication of the parasympathetic withdrawal (as indicated by the RSA response) being the primary diving factor behind the increases in HR as opposed to a combination with SNS activation. However, GSC, which, like PEP, is specific to SNS activity, did reflect an increase in SNS activation from anticipation to stressor, therefore not directly supporting the timing indicated by PEP. However, as mentioned previously, SNS or PNS activations do not necessarily involve completely all-or-nothing uniform signaling across all target organs. Therefore, this difference in GSC and PEP may simply reflect slightly differential activation of the SNS across target organs. Regardless of these minor discrepancies, each of the 4 indices still certainly support the interpretation that parasympathetic withdrawal and sympathetic activation occurred in response to the stressor. While a lack of *exact* convergence across all ANS measures may indicate some differential effects found across indices of ANS due to differential timing of hormone signaling and the resulting target organ effects, this was anticipated and has been discussed in previous literature (see Sapolsky, Romero, & Munck, 2000). In general, the overall integration of the data across indices still strongly indicates the presence of an autonomic stress response to the TSST.

This same typical sympathetic stress response has been also been researched heavily in real world stressor settings (Allison et al., 2012; Dobkin & Pihl, 1992; Healey & Picard, 2005) as well as animal models (Hermann et al., 1994; Koolhaas, De Boer, De Rutter, Meerlo, & Sgoifo, 1997) and is conceptualized as developing via evolutionary adaptation through natural selection of the "fight-or-flight" response to challenge or stress. With regard to the functioning of physiological and psychological mechanisms within our bodies, the evolutionary importance for survival and the resulting innate nature of these ANS responses to stress supports their relevance to human functioning today, even in modern contexts (i.e., psychosocial stress) that differ greatly from their original uses for fight-or-flight to increase survival in the face of immediate danger (e.g., running from a predator).

Do the coded behaviors load into factors as predicted?

Figure 12. Predictions of factor loadings and actual loadings from our analysis.

This figure shows how we predicted behaviors (green boxes) would load together into factors of coping domains (green dotted ovals), how behaviors actually loaded into the factors we extracted (blue ovals), and the relative strength of behavior (blue boxes) loadings within factors (items closer to factors signifies stronger association). Green arrows show the 4 behaviors that loaded as predicted (i.e., laughing, smiling, mumbling, and lack of deep breaths which showed a negative association) while red arrows were used for factors that appeared to load differently than predicted originally (8 behaviors). Dashed green arrows reflected loadings that did not occur exactly as predicted but were still reflected to a degree in the findings through loading together in an inverse way on another factor.



Though at first glance, it may appear that our hypothesis was largely unsupported with regard to factor-behavior specific predictions, the loadings still seemed to group in ways that supported a coping-related interpretation of their occurrence. Figure 11 illustrates our predictions for factor loadings as well as how behaviors loaded onto extracted factors and the relative strength of those associations as indicated by our results.

While most items did not load exactly as predicted, their initial categorizations were largely exploratory and based on conjecture, not prior empirical literature due to a lack of previous studies conceptualizing these types of acute behaviors as related to coping. However, our interpretation of the factors does seem to make sense with regard to integrating these acute behaviors into the typically trait-based heavy coping literature. Factors that were extracted appeared to reflect similar coping domains to those originally predicted including Emotion-Oriented (EO) coping, Nervous Behavior (NB) coping, Passive Avoidant (PA) coping, and Active Avoidant (AA) coping.

Our first prediction was that problem-focused coping would be reflected by gestures and a lack of silence. These items did load together, but were weighted more heavily in the inverse direction towards a lack of gestures and silence. Though problem focused coping was not directly captured by any of the factors, it is likely to be at least be partially signified by low scores on Passive Avoidant coping (suggesting more gesturing and therefore a more engaging or enthusiastic speech). It also would make sense to conceptualize Passive Avoidant coping as a "lack of problem-focused coping". Due to the intentionally uncontrollable nature of the TSST, it may logically follow that problem-focused coping strategies, which are typically used in response to conditions that are perceived as controllable (Lazarus, 1993; Lazarus & Folkman, 1987), might be rarely used in a stressor that is designed to be an inescapable challenge that is difficult to address with problem-focused behaviors. Though not examined in study, the inclusion of global ratings such as convincingness, enthusiasm, or effort during the speech might assist in creating a way to measure the presence (as opposed to lack thereof) of problem-focused coping during the TSST.

Next, we predicted that an Inward-Emotion factor would include items like laughing and smiling. These items were clearly captured by the Emotion Oriented factor. Laughing and smiling have been used often as acute behaviors in past research to reflect positive emotional coping to emotion inducing (Tsai, Levenson, & Carstensen, 2000) and stress inducing tasks (Winstead, Derlega, Lewis, Sanchez-Hucles, & Clarke, 1992). However, Emotion Oriented coping did not include the predicted items nervous tone or interjections, though these items did load together on the Nervous Behavior factor suggesting that observation of emotion oriented responses is complicated in the context of the TSST.

In addition to being primarily characterized by laughing and smiling, Emotion Oriented coping also included, though with weaker associations, irrelevant questions or statements and looking away or down that were originally expected to reflect active avoidance. However, these behaviors still could still be interpreted as emotion oriented in that they reflect behaviors that tend to involve self-reflection of emotional states. For example, saying the frequently observed irrelevant phrase "this is hard" indicates one's own perception of the emotional distress he is experiencing in response to a stress-inducing task. Being silent also slightly loaded onto this factor, but the association was small and was largely ignored because silent cross loaded more strongly with Passive Avoidant coping.

An outward-emotion factor was predicted to be characterized by defiant/non-compliant behavior because of our observation of participants occasionally exhibiting behaviors reflecting outward anger and frustration and a resistance or overt refusal to follow instructions (e.g., "You still have time. Please continue.") given by the confederates. However, the Defiant/Non-compliant behavior was excluded from the factor analysis because of such a low frequency of occurrence (90%) of participants did not exhibit the behavior at all) and the resulting severely skewed distribution of scores and lack of variance. With a larger sample size, this factor may be able to emerge in future studies.

Next, we predicted that a Passive Avoidance factor would include many items that reflected introspection and self-distraction tendencies in response to task demands. Silence and swaying items loaded as predicted into the Passive Avoidant coping factor. In addition to silence and swaying, this factor was most strongly associated with a *lack* of gesturing. Though not included as a predictor originally, the association of a lack or gesturing behavior (a problem-focused behavior) is understandable in this grouping of a factor characterized by coping that involves avoiding rather than overcoming stressful or difficult tasks. Though originally predicted to be included in this factor, looking away, interjections, and mumbling loaded separately into Emotion Oriented coping, Nervous Behavior coping, and Active Avoidant coping respectively.

Lastly, we predicted that Active Avoidant coping would be characterized by irrelevant questions or statements during the task employed as a means to intentionally avoid or distract from the task. As discussed previously, however, irrelevant phrases was captured by emotion oriented coping, likely due to the higher-than-expected frequency of emotional reflection related comments that were deemed irrelevant phrases (e.g., "This is hard", "I really hate public speaking", etc.). This item would have perhaps loaded as expected if only more emotionally neutral types of questions or statements had been observed (e.g., "How much time do I have left?).

In general, our obtained Active Avoidant coping included behaviors that involved a more distraction oriented type of active avoidance such as fidgeting, mumbling, and a *lack* of taking deep breaths. While taking deep breaths could be seen conversely to active avoidance in that the participant may be trying to compose themselves and keep up their effort at the speech, deep breaths may have also negatively loaded onto this item due to the possibility of observer error. This item's validity may be questionable due to the subtlety of the movement of taking a deep breath and a lack of sufficient level of video quality to be able to clearly and easily notice the chest expanding.

Nervous Behavior coping was characterized by seemingly anxious or nervous verbal behaviors including nervous tone of voice, excessive interjections, and stuttering or stammering. Though not specifically predicted as a factor beforehand, this factor does reflect some characteristics and items that we would expect. As mentioned above, the fact that the inward-emotion predicted variables of stuttering and nervous tone loaded strongly together onto this factor may indicate that the TSST complicates the observation of inward-emotional coping. In addition, the captured excessive interjections item was predicted to load onto passive avoidant. The fact that the observation occurs during a socially evaluated speech task in which participants are instructed to speak continuously throughout may drive the association between these vocally expressed paralingual (i.e., tone, pace, etc. of speech) and verbal behaviors. With this explanation in mind, it becomes more feasible to conceive of Nervous Behavior as a paralingual factor that is mostly reflective of emotional states as expressed through tone of voice (i.e., nervous tone) and the fluidity and continuity of spoken words and phrases (i.e., stuttering and interjections). Paralingual cues such as these have been studied more recently in the emotion literature, many having the goal of furthering understanding the cross-cultural universality and, therefore, innate nature of emotional expression through vocal yet non-verbal cues (Sauter, Eisner, Ekman, & Scott, 2010; Scherer, Banse, & Wallbott, 2001). These types of preliminary findings help to emphasize the importance of observing such behavioral reflections of outward emotional expression as well as unconscious exhibition of internal emotional states.

Are the coping strategies associated with ANS levels and reactivity?

A few interesting associations were found between coping strategy scores and ANS reactivity. Active Avoidant coping during the speech was found to be associated with simultaneous (speech) and immediately following (math) HR levels. Nervous Behavior during the speech was associated with previous RSA levels during anticipation, suggesting a link between parasympathetic activation and subsequently exhibited nervous verbal behaviors. These results were from preliminary bivariate correlations conducted to determine what associations, if any, might found. Due to the reactive nature of the ANS in response to an acute stressor such as the TSST, associations controlling for time give us more meaningful information with respect to how coping may affect the ANS across conditions with varying degrees of exposure to a stressful context.

Participants who exhibited more Active Avoidant coping during the task had buffered increases in HR during the task and more quickly returned to baseline HR levels following the task. Active Avoidant coping was also associated with RSA such that reactivity patterns from baseline to anticipation to speech in those exhibiting the highest Active Avoidant coping were inverted compared to normal. That is, while the typical RSA response was an increase from baseline to anticipation and a decrease from anticipation to speech (see Figure 6), participants who exhibited the most Active Avoidant coping had RSA decrease then increase (see Figure 9). Together, these findings indicate that Active Avoidant coping as characterized primarily by fidgeting and mumbling buffers an SNS response by maintaining (and slightly increasing) parasympathetic control throughout the TSST. These findings have not been largely supported by past research on anxious behavior, such as fidgeting, and anxiety disorders; in contrast, research typically associates anxious behavior with exaggerated or prolonged autonomic responding in general (Boyce & Ellis, 2005; Hammen, 1991). Though contrasting with this literature, our findings suggest that the salient yet uncontrollable stressful context of the TSST is one in which these types of behaviors may inhibit ANS activation. The actively avoidant, self-distracting nature of these behaviors may allow for them to act as buffering coping mechanisms in this specific context. Alternatively, if these participants (i.e., those higher on Active Avoidant coping) were to be characterized as people who are anxious and fidgety normally, even while not under acute stress, they're prior frequent exposure to increased autonomic activation or arousal may buffer the re-appraisal and positive feedback initiated in response to the TSST. More specifically, their own heightened anxiety and familiarity with the resulting autonomic effects could perhaps decrease the novelty and therefore salience of the initiated (though blunted) stress response. However, this speculation about the continuous reappraisal of one's own internal response to stress is complicated by the literature findings which are mixed with regard to an individual's ability to successfully perceive and validly interpret his or her own levels physiological responding (Callister et al., 1992; Eck et al., 1996; Pruessner et al., 1999). Another interesting comparison of these findings is to studies examining emotion suppression which indicate heightened sympathetic arousal in individuals who are told to consciously inhibit the expression of their emotions in response to emotional stimuli (Butler et al., 2003; Gross & Levenson, 1993). Similarly, in the context of a marital conflict, men who suppress their emotional expression demonstrate heightened autonomic responding (Gottman, 1993; Gottman & Levenson, 1988). Given that suppression of emotional states is shown to increase autonomic responding, it follows that the ability and tendency to express one's emotional state while under stress (such as through exhibiting behaviors like fidgeting) can buffer autonomic responding. Both of these indications (i.e., that AA buffers ANS and a lack of AA increases ANS responding) are supported by our findings. An important consideration here to reemphasize is that of the resulting buffered ANS effects supporting our interpretation of these behaviors as coping.

In contrast to the Active Avoidant association with RSA, Nervous Behavior coping, as characterized by nervous tone of voice, interjections, and stuttering, was associated with an amplified decrease in RSA as well as elevated levels of RSA at rest. Keeping the timing of the observed Nervous Behavior coping in mind, the increased parasympathetic activation in anticipation of the stressor seems to predict impending Nervous Behavior coping while the significantly amplified parasympathetic withdrawal (i.e., autonomic arousal) during the task is associated with a simultaneous display of Nervous Behaviors. Here the significant parasympathetic withdrawal seems to cause an increased display of nervous paralingual behavior. Though not a significant effect, higher Nervous Behavior was also associated lower HR pre-task and elevated HR during speech and therefore a slightly increased amplification of HR due to the stressor. Similar, though again non-significant, effects were observed in PEP with amplified decreases at the stressor (through inverse directions compared to HR, indicating the same directionality of SNS activation). Though still mostly indicated by the effects of RSA alone, together this information indicates that increased parasympathetic withdrawal and sympathetic arousal in response to the stressor may cause an increase in Nervous Behavior. This is highly consistent with emotional research which tends to highly correlate emotional and physiological arousal with paralingual activity (Ekman et al., 1983; Sauter et al., 2010; Scherer et al., 2001). If mistakenly considering that “coping” should imply a buffered response, this may appear to indicate a weakness of this particular factor as being coping because no blunted effect was observed. However, it is essential here to restate our use of Lazarus' (1984) operational definition of coping as the "constantly changing cognitive and behavioral efforts to manage specific external and/or internal demands that are appraised as taxing or exceeding the resources of the person." This behavioral change following physiological responding is therefore still coping as we have defined it.

Emotion-oriented coping as indicated by primarily by laughing and smiling was associated with GSC such that those who exhibited the most Emotion Oriented coping had heightened GSC increases from baseline to anticipation and across the duration of the stressor (from speech to math intervals). This again implicates sympathetic responding as being closely correlated with emotional behavior, which, as discussed above, is highly consistent with the literature (Ekman et al., 1983; Sauter et al., 2010; Scherer et al., 2001). Perhaps a distinguishing factor here is that the recognition and appraisal of one's own outwardly nervous behavior (i.e., laughing and smiling) may act as a catalyst for further increasing sympathetic activity throughout the duration of the stressor.

Implications

Findings from the present study implicate several contributions. First, the findings reflected by our ANS measures support the use and further validation of our modified version of the Trier Social Stress Test because of its ability to reliably elicit autonomic stress responding in participants. This is an important consideration in the methodology of acute laboratory stressors. Second, the factor analysis of our observed behaviors supported the interpretation of these items as reflecting acute coping during the TSST. Third, our specific findings with regard to how certain coping domains interact with physiological reactivity to acute psychosocial stress implicate the importance of considering the effects and interaction of physiology and behavior in the context of an acute stressor (as shown in Figure 1). With respect to intervention or prevention related application, these findings implicate the importance of identifying, as well as validating the observation of, behaviors and coping styles that could possibly be used (via treatments or training such as CBT or biofeedback) to treat psychological or health-related problems that would be alleviated by being able to successfully buffer one's own psychophysiological stress.

Limitations

One limitation of the present study is that we did not observe behavior at time points other than during the stressor. This would have allowed for us to control for behaviors that were not specific to the stressor condition and were merely persisting behaviors that participants exhibited across conditions. However, this was somewhat addressed through the initial development of our coding scheme which involved, prior to implementation, watching TSST videos to systematically note frequencies of behaviors across participants in order to be able to adjust and specify benchmarks for coding specific degrees or frequencies of behaviors that reflected the expression of elevated internal stress.

Another methodological limitation of the study was that certain segments of autonomic data were too noisy to be cleaned or interpreted. However, this type of issue is relatively common in psychophysiological research, especially in cases where more movement of the participant is involved, though is still generally not considered a significant problem. Including additional validated indices of ANS activity such as Left Ventrical Ejection Time (LVET), stroke volume (SV), or cardiac output (CO) could allow for an even broader consideration of ANS activity.

Another possible limitation was the degree of detail that the videos displayed of the participants. Having multiple camera angles with ranging degrees of zoomed or magnified shots would have possibly allowed for more valid usage of the currently employed coding scheme or even the possible development of a more detailed coding system that captured more behaviors and more information (e.g., emotional information via facial expressions). With respect to emotional information that was collected, the use of additional physiological indices such as facial electromyography (EMG) could demonstrate significantly more breadth and specificity of emotional expression and possibly suppression. However, the use of electrodes on the face during a psychosocial stressor might be hindering for the participant, possibly affecting their perception and appraisal of the normally salient stressor, not to mention their performance.

In the future, the use of statistical methods that allow for more time-sensitive analysis (e.g., Hierarchical Linear Modeling) would allow for interpreting more specific and detailed associations between coping and autonomic activity over time, both of which could be concurrently associated across 30-second epochs as opposed to the averaged 5-minute periods used in the current study. Furthermore, the addition of HPA axis indicators (i.e., cortisol levels) to the study would demonstrate the effects (or lack thereof) of coping behavior on this slower endocrine signaled pathway of the stress response.

Conclusion

The current study supported the conceptualization of a cyclical relationship between external stressors, acute physiological stress, and behavioral expression (i.e., coping). We found that our modified version of the Trier Social Stress Test was reliably induced a stress response as indexed by ANS reactivity. Coping was found to be an observable construct of behaviors in an acute setting. Finally, coping was found to be associated with certain ANS responding to a stressor. Further study of additional or alternative indices of behavior and their relationship across multiple SRS indicators (i.e. HPA & ANS) in the context of laboratory and real-world stressors is needed to further disentangle these types of hormone-behavior-environment relationships that are at the core of the study of biopsychology.

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TSST Stress Coping Behaviors Coding Manual

Please fill out the corresponding information at the top each coding sheet as follows:

ID#	ID # of participant
Sex	Biological sex of participant
Date of Visit	Date of participant visit
Date Scored	Date on which video is being coded/scored
Scorer	Name of Scorer
Begin Time (within video)	Specify starting time of the TSST speech task within the video's time span. Ex: 2 min 3 seconds (after the start of the video)
Begin Time (TOD of video starting)	Specify the **time of day** that the video is starting. This can be approximated closely by watching the video on the mindware files.

All videos will be watched twice. First, watch the video with the volume muted and code behaviors under the "Physical" behaviors block. Next, watch the video with volume turned up to a reasonable level using headphones and code the "Verbal" behaviors block.

For all behaviors listed below, code a "1" to signify the behavior was performed during that particular epoch. Otherwise, code a "0" during that epoch.

Speech Task (Physical)**:** 30 second epochs	Epochs are 30 second intervals of time.
Looking away or down	Code if the participant looks away or down for **3 or more Seconds** (total in single epoch). -BUT if the look is very overt, but slightly shorter in duration, still code a 1 (yes)

Gestures	Refers to **intentional** gestures or movements that, if repeated, are repeated less than 5 times in a row (within a brief period of time). The focus of these movements is usually a participant's arms and hands, but can also include full body movements if the movement is intentional and serving some purpose to emphasize what they are saying in their speech.
Fidgeting/ Stereotypy	Stereotypy refers to a **repetitive movement** that is repeated at least **5 or more times** (immediately after one another, within a brief period)**.** Also be sure to code instances of fidgeting. Examples of fidgeting include **touching one's back, touch/playing with the electrodes, rubbing one's nose/face, etc.** If there is only one instance of fidgeting and it is very short (~3 seconds or less), coding a 1 (yes) may not be appropriate. Use your own judgment when deciding if a short instance of fidgeting is a nervous behavior (code yes) or just a momentary extension of a gesture (code no).
Swaying/ Shrug	This item captures movements of the torso. For swaying, code a 1 (yes) only if they sway back and forth (in both directions) at least **twice** (2 times in each direction) within an epoch (this is to distinguish swaying from simply shifting weight occaisionally). Also code a 1 (yes) if they **shrug** their shoulders.
Smiling	Code a 1 (yes) if they smile during the epoch.
Deep breath/ Swallows	Mark this item if they take a deep breath or if they swallow.
Other	Here specify any other **physical** behaviors that seem to signify stress or coping with stress
	Examples: "licks lips", "bites lip", etc.

Verbal block

Mumbles/ Whispers (0 = no; 1 = yes)	Code a 1 (yes) if they **mumble** or **whisper** for **~ 3 seconds or more**.
Laughing	Code a 1 (yes) if they laugh at all during the epoch.
Silent	For this item, use the speaking confederate's audio as a cue. If the confederate says anything such as "please continue" or "you still have time", automatically code a 1 (yes) for that epoch. If, for some reason the confederate is not saying "please continue... (etc.)", but the participant is silent for more than **10 seconds**, code a 1 (yes) for that epoch.

Stuttering/ Stammering/ Corrects Speech	**Stuttering/stammering** should be coded only if they stutter on a syllable at least **3 times** for a word/syllable**. Corrects Speech** should be coded only if they correct themselves **3 or more** times within an epoch (ex: correcting misused or mispronounced word, saying "I mean…"/"I meant to say…", etc)
Interjections	Examples of interjections include words/sounds such as **umm, and, okay, well, like, etc**. Use **5 or more** interjections within an epoch as a benchmark for coding a 1 (yes).
Nervous Tone	Code a 1 (yes) if their **tone of voice** (not content of their speech) seems nervous to you (ex: nervous high pitched inflections, shaky voice, etc)
Ask irrelevant questions/ Says irrelevant statements	Code a 1 (yes) if they ask any irrelevant questions or say any irrelevant statements. Examples: • "How much time do I have left?" • "I don't know what to say…" • "This is hard…" • Etc.
Defiant/Non-compliant	This item should be coded when a participant is **not following instructions on purpose**, or if they have a **defiant attitude** in their **speech content** or **tone** in their voice. This would also include instances where the participants don't seem to be taking the task seriously and are blowing it off. Examples of things they might say include: • "I'm not doing this anymore" • "This is stupid" • Etc.
Other	Here specify any other **verbal** behaviors that seem to signify stress or coping with stress

Vita

The author received his B.S. in psychology from the University of New Orleans in 2010. In his time as an undergraduate student at UNO, he began doing research in the SPIT lab with Dr. Elizabeth Shirtcliff studying the physiological and psychological effects of skydiving on novice and experienced jumpers. He subsequently worked on the present project involving a modified version of the Trier Social Stress Test that looked at the hormonal and autonomic stress responses of individuals experiencing a social-evaluative threat. As a biopsychology graduate student, Jeremy hopes to continue examining the effects of stress on people's physiology, emotions, and behavior and how these factors intertwine with others such as temperament, environmental context, and cognitive deficits.