Psychophysiological Responses to Emotion Priming

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Spring 2019

Acknowledgements: This research was supported by the Lindquist Undergraduate Research Fund from the Department of Psychology and Neuroscience at UNC Chapel Hill. I would also like to thank my graduate advisor, Holly Shablack, and my faculty advisor, Dr. Kristen Lindquist.

A thesis presented to the faculty of UNC Chapel Hill in partial fulfillment of the requirements for the Bachelor of Science degree with Honors in Psychology.

Abstract

Psychological constructionist theories such as the Theory of Constructed Emotions (TCE; Barrett, 2014), suggest that emotions are a constructed phenomenon dependent upon more basic factors: core affect and concept knowledge. I test this view by manipulating both core affect and accessibility of concept knowledge and examining subsequent emotion experiences. Importantly, I draw on both behavioral and physiological stress responses of challenged and threatened states to examine cardiovascular reactivity and recovery. While gathering cardiac performance data, participants' (N=34) physiological states were manipulated to a highly negative and activated state through the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). Prior to the TSST, individuals were primed with an emotion concept (e.g., anger, embarrassment). Behavioral measures, as predicted, showed that participants in the anger condition made more external attributions. Physiological results, although not significant, showed beginning evidence of difference in cardiac performance dependent upon concept prime. These findings indicate that, as per the TCE, language can impact subjective experiences of emotion. This has important implications in the context of psychological illnesses related to emotion, such as anxiety disorders, as well as resiliency and recovery from general stress.

Keywords: emotion construction, priming, challenge, threat, physiology, attribution, recovery

Psychophysiological Responses to Emotion Priming

Since the rise of modern psychology, the study of emotion has been at the center of a controversial scientific debate (for review, see Lindquist et al., 2013). The depth and variety of emotions we experience on a daily basis have prompted investigations into the origin, perception, and universality of this elusive concept. One class of theories on the nature of emotion are basic emotion theories. Theories within this framework posit that emotions are marked by corresponding neurophysiological states (Ekman, 1992; Panksepp, 1982). In other words, emotions cause physiological states and reactions that are innate and universal across all individuals. In contrast, the James-Lange theory proposed during the 19th century theorized that emotions were distinct feelings created in response to stimulated physiological changes (James, 1884; Lange, 1885). This hypothesis, that a particular neurophysiological state was indicative of a specific emotion, remained fundamental to emotion theory several years later (Johnson-Laird & Oatley, 1992). Much of the general public and scholars alike supported the idea that certain emotions could be explained by their more basic and innate responses, although the direction of this relationship remains under debate.

More recently, psychological constructionist theories have expanded on traditional theories of emotion and provide evidence that emotions are a constructed phenomenon dependent upon a number of more basic factors. Specifically, the Theory of Constructed Emotions (TCE, formerly known as The Conceptual Act Theory; Barrett, 2014, Lindquist, 2013) posits that emotions are constituted of more basic psychological components: core affect and concept knowledge. Core affect refers to physiological sensations with varying degrees of valence and arousal. Concept knowledge refers to previous experiences that can influence thought processes, beliefs, and actions. These two interact and general affective states are

interpreted based on concept knowledge, and this interpretation leads to the subjective experience of an emotion (Barrett, 2009; Lindquist, 2013; Lindquist, Siegel, Quigley, & Barrett, 2013). Emotions are therefore not representative of distinct neurophysiological patterns, nor are they products of neurophysiological patterns alone, as basic emotion theory and earlier theories of emotion propose, but rather products of complex neural pathways that are formed based on the interaction of core affect and conceptual knowledge (Barrett, 2014).

The research presented here tests the psychological constructionist view and aims to understand how conceptual knowledge prompts specific emotion experiences after manipulating core affect. Prior research shows that when concepts are made more accessible to an individual, their experiences, including emotion experiences, can be altered (Lindquist & Barrett, 2008). Access to emotion concepts or lack thereof, impacts individuals' ability to quickly and accurately perceive emotions in others (Gendron et al., 2012; Lindquist, 2006) and acquire novel emotion concepts (Doyle & Lindquist, 2018). A second component of our study relies on the manipulation of core affect. This manipulation relies on evidence examining the physiology of challenge and threat in response to stressors (Blascovich & Mendes, 2010). Challenge and threat are two motivational states that are theorized to impact how individuals respond to stressors. A challenge state occurs when perceived resources exceed situational demands and a threat state occurs when situational demands exceed perceived resources (Blascovich & Mendes, 2010). These two states have been observed to influence common processes such as decision-making and social comparison and are marked by certain behavioral and physiological profiles (Mendes, Blascovich, Lickel, & Hunter, 2002; Mendes, Blascovich, & Seery, 2001). Further investigation into challenge and threat states could provide insight into our subconscious perceptions and, in turn, our psychological reactions—especially emotions.

We aim to use quantitative measures, generating further confidence in any observed trends, to assess emotion experiences. In the following report, I investigate the qualitative and quantitative nature of perceptions of a negative, highly activated physiological state as either challenge or threat states, as a consequence of discrete emotion concept priming. Furthermore, I analyze physiological recovery to determine the extent of their impact and implications to resiliency and vulnerability.

The Theory of Constructed Emotion

The Theory of Constructed Emotion (TCE, formerly known as The Conceptual Act Theory; Barrett, 2014, Lindquist, 2013) hypothesizes that emotions are embodied when an individual unconsciously uses concept knowledge to make sense of their core affect. Concept knowledge is learned from sources such as socialization, language, upbringing, and other cultural factors that could influence subjective perception of the environment. This learned knowledge is then subliminally "activated" when sensory and motor neurons fire in response to a stimulus (Barrett, 2014). For instance, an individual could perceive an ambiguous figure in the dark as a lamp post or a thief (based partly on the environment and partly on previous experiences). This in turn would activate different physiological systems, such as increased sympathetic activation in the case of the perceived thief. The combined effect of perception and core affect would then lead to some emotional experience, perhaps fear or shock in this case. This interaction also occurs in the inverse relationship, where individuals may make meaning of their core affect with concept knowledge and their current environment. In summary, the TCE suggests that the brain routinely uses interactions between the environment, core affect, and an individual's concept knowledge to contextualize an affective experience as an emotional event. As such both one's

physiological state and bodily sensations (core affect) and concept knowledge are key in emotion construction.

Core affect and language. Constructionist theories suggest that affect can have varying degrees of valence and arousal and contribute to the embodiment of an emotion (MacCormack & Lindquist, 2017). By providing peripheral information such as blood pressure and heart rate, affect serves as an indirect representation of central nervous system processes, specifically ones that interpret and respond to provoking stimuli. Under this framework, core affect can provide neurophysiological information on constantly changing body states. This component is crucial to the TCE as high-arousal, low-arousal, and other affective states are interpreted by means of concept knowledge, leading to an emotion experience.

As suggested earlier, concept knowledge arises from various cultural and environmental factors. Constructionist models suggest that one such factor, rooted in the concept of emotion itself, is language (Lindquist, 2009; Doyle & Lindquist, 2018; Lindquist, Barrett, Bliss-Moreau, & Russell, 2006). While languages across cultures may not define emotions in the same way, they all possess "emotion categories" that correspond to positive (pleasant) or negative (unpleasant) affective states (Lindquist, 2009). Therefore, from an early age, language plays a fundamental role in concept knowledge and subsequently emotion perception, by serving as an "essence placeholder" cohering together all of the cultural relevant information of an emotion category for an individual. The role of language in concept knowledge is evidently crucial to emotion perception. Studies demonstrate a link, for example, between language and accuracy in judging facial expressions depicting emotion (Gendron et al., 2012; Lindquist et al., 2006) and language, in the form of words, helping adults acquire novel emotion categories (Doyle & Lindquist, 2018). Furthermore, faces with morphed expressions of happiness and anger were

interpreted as being more angry than happy when they were associated with the word “angry”, showcasing that having a particular concept in mind can shift perceptions of emotions in others in the moment (Halberstadt & Niedenthal, 2001).

Since the TCE specifically theorizes an interaction between core affect and concept knowledge, then if an individual’s concept knowledge accessibility is manipulated (by making a concept more accessible through priming), their perception of their core affect and subsequently their emotional experience should change. Lindquist and Barrett (2008) demonstrated that participants were more likely to report higher levels of risk aversion when primed with conceptual knowledge of fear and manipulated to feel unpleasant, high arousal. Participants’, physiological arousal levels were interpreted differently based on the concept knowledge made accessible to them (anger v. fear), showcasing that concept accessibility can shift around perceptions. As such, it is possible for individuals to adjust how they may perceive high arousal states such as stress. To inform the expected patterns and physiological changes of a high arousal negative state such as stress, in the context of the TCE, we turn to the biopsychosocial model of challenge and threat (BPS; Blascovich & Mendes, 2010).

Perception and Physiology of Challenge and Threat

According to the BPS, situations that are goal-oriented produce psychological states that are based on continuous evaluations of two factors: situational demands and personal resources to meet these demands. Factors such as danger (both psychological and physical), familiarity, effort, and personal confidence can affect individual interpretations of situational demands and resources. When perceived resources exceed situational demands, the individual experiences a challenge state; when situational demands exceed perceived resources, the individual experiences a threat state. The BPS suggests that certain physiological indexes and behavioral

patterns can be used to discern a challenge vs. threat state. Challenge states are associated with greater sympathetic activation, resulting in increased ventricular contractility and cardiac output alongside decreased peripheral resistance. Ventricular contractility refers to the rate at which ventricles pump blood and cardiac output is the amount of blood pumped by the heart. Both can be examined via physiological measures such as blood pressure and electrocardiography. Largely, as individuals feel ready to take the task at hand, their body reacts in a way to prepare them to tackle the situation – physiologically this means increased blood flow to their extremities resulting in the aforementioned conditions. Therefore, one may see increased heart rate and blood pressure. In contrast, in threat states, individuals are aiming to conserve their energy, resulting in a restriction in blood flow, marked by increases in sympathetic activation but also larger increases in HPA activation, thus, causing decreased efficiency in cardiac responses; specifically: minimal change in cardiac output, increased ventricular contractility, and increased peripheral resistance (Blascovich & Mendes, 2010). Here, one would expect to see decreased heart rate and blood pressure.

RSA (respiratory sinus arrythmia), which is heart rate variation during a normal breathing cycle, is another physiological measure that can be used to mark challenge and threat perceptions. According to Porges Polyvagal Theory (2007), low RSA is associated with increased sympathetic activity, increased heart rate, and rapid breathing while high RSA is associated with decreased sympathetic activity, decreased heart rate, and controlled breathing. Because the BPS suggests greater sympathetic activity for perception of a challenged state, this would mean that lower RSA would be associated with perception of this state as well. Similarly, as the BPS suggests decreased efficiency in cardiac responses for threat states, a higher RSA would be associated with a threat state.

An individual's perception of challenge and threat, i.e. their evaluations of resources and demands, also impacts their behavior. For example, when perceiving a stressor as a challenge, individuals are more likely to partake in behaviors showcasing more other-focused emotions like, anger and even pride and provide more external attributions for their own behavior. This includes less perceived control, leading to an increase in blame towards others for their own performance or the situation. Those who perceive threat partake in behavior that showcases more self-focused emotions, like embarrassment and anxiety, and provide more internal attributions for their own behavior. This results in increased perceived control which leads to more blame towards the self (Blascovich & Mendes, 2010).

Recovery. The BPS also theorizes particular recovery patterns with challenged and threatened states. This is particularly informative and important to debilitating psychological disorders, such as anxiety or PTSD, as it provides a quantitative measure of vulnerability to certain stressors (Brosschot, Gerin, & Thayer, 2006). Understanding recovery from general states such as challenge and threat could provide information about which types of stressors have the greatest psychological impact and if theses perceptions can be easily manipulated with accessibility of concept knowledge, which could open a new direction of therapy. Research suggests that the general physiological profile of threat states tends to cause more damage to certain biological systems than challenge states. Specifically, those who experience prolonged threat responses have increased rates of biological aging based off of measures with telomerase (chromosome-extending enzyme). This effect has been directly related to stress-related diseases such as hypertension and cardiovascular disease (Epel et al., 2018). Based on this research, it is evident that susceptibility to stress can play a role in recovery capability. Blascovich and Mendes (2010) define this capability as adaptive and maladaptive states.

Adaptive vs. maladaptive states correspond to "physiological toughness." According to Blascovich and Mendes (2010), the distinction between these two states lies primarily in baseline levels and recovery. Specifically, adaptive profiles are consistent with low baseline CV (i.e. low heart rate), immediate increases in response to a stressor, and a quick recovery. In contrast, maladaptive states consist of slow increases in activation over the course of a certain task, followed by a slow recovery period (Blascovich & Mendes, 2010). Seery (2011) proposes a similar model to adaptive vs. maladaptive states: resilience vs. vulnerability. In general, resilience refers to successful adaptation in the face of a perceived stressful experience, whereas vulnerability reflects lack of successful adaptation (Seery, 2011). Studies suggest that resilience arises from evaluations of high resources and low demands, while vulnerability to the same stressors leads to evaluations of low resources and high demands (Weisbuch, Mendes, Seery, & Blascovich, 2005; Seery, Blascovich, & Weisbuch, 2008). Therefore, based on the biopsychosocial model, experiencing challenge and threat could be reflected in experiencing resilience and vulnerability respectively. Understanding these two states could provide beneficial insight into susceptibility for stress.

Proposed Study

To better understand psychological and physiological responses to challenge and threat, I will incorporate a study design with roots in psychological constructionist theories (specifically, the TCE) by manipulating both an individual's physiological state and concept knowledge. While gathering individuals' heart rate and respiratory sinus arrythmia (RSA), participants' physiological state will be manipulated to a highly negative and activated state, through the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). The TSST is a motivated performance task that has been found to induce increased levels of activation and physiological

arousal in participants (Kirschbaum, Pirke, & Hellhammer, 1993; Het, Schoofs, Kirschbaum, Wolf, 2009). Importantly, prior to the manipulation of core affect, individuals will be primed with an emotion concept (anger v. embarrassed v. two control conditions), a manipulation of concept knowledge. We chose anger and embarrassed primes because of their previous link with external and internal attributions, as well as challenge and threat states. As such, we predict that anger will elicit a more challenge-based perception of the stressor and embarrassed a more threat perception. Following the TSST, participants complete a series of self-reported behavioral measures to provide information on attributions and emotion states.

Based on prior literature, I hypothesize that those primed with anger will exhibit a challenge physiological profile (increased heart rate and lower RSA compared to baseline levels) as well as self-reported affective and behavioral responses (reports of less control and more blame towards others). Associated with this will be the fastest recovery time, since resilience is associated with challenge states. Likewise, if the embarrassed prime induces a threat state, it will manifest according to the threat profile (minimal change in heart rate and higher RSA compared to baseline levels) and longer recovery times, as well as self-reported affective and behavioral responses (reports of more control and less blame towards others). As discussed earlier, vulnerability is associated with threat.

Methods

Participants

This study is part of an ongoing project with a target sample of 200. Participants were recruited through the University's Introduction to Psychology subject pool and granted 1-3 credits for their participation. For these analyses, we examine a subset of the ongoing study that have cleaned and scored physiological data for electrocardiography for measures of heart rate

and RSA, and were in the anger and embarrassed concept prime conditions resulting in 34 participants (M_{age} = 19.45, SD_{age}=1.73; 10 female; 20 anger condition).[1] The sample was largely Caucasian (82.4%) and first (47.1%) and second year students (29.4%). All participants met prior inclusion criteria.

Procedure

Participants completed two sessions. The first session was completed either in person or online wherein individuals complete a series of questionnaires and an eligibility screening. This session lasted for approximately an hour and occurred on a day preceding Session 2, which lasted for approximately two hours.

Session 1. Participants completed an initial survey containing a number of questionnaires on emotion experiences, behavior, and attitudes. Participants are also screened for eligibility requirements for Session 2. The survey is completed online and can be completed in the participants' own time, or in the laboratory. Following consent, the survey randomly presented questionnaires measuring interoceptive awareness (Multidimensional Assessment of Interoceptive Awareness Mehling et al., 2012); Body Awareness Questionnaire; (BAQ; Shields, Mallory, & Simon, 1989)) , emotion concept knowledge and granularity [Toronto alexithymia scale (TAS-20; Bagby, Parker, & Taylor, 1994), range and differentiation of emotional experiences scale (Kang & Shaver, 2004)], social phobia and anxiety [Social Phobia Inventory (SPIN; Connor et al., 2000), Brief Fear of Negative Evaluation (BFNE; Leary, 1983) and State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970)] and other facets of emotion such as regulation [Emotion Regulation Questionnaire (ERQ; Gross & John, 2003)] and intensity [Emotional Intensity Scale (EIS; Bachorowski & Braaten, 1994)]. Additional measures

[1] Due to inability to match some IDs with their completed session 1 and participant error (not properly indicating their SONA ID on the online questionnaire), demographics from four of the 34 are missing.

of anger rumination [the 19-item Anger Rumination Scale (ARS; Sukhodolsky, Golub, & Cromwell, 2001)], guilt and shame proneness [the Guilt and Shame Proneness Scale (GASP; Cohen, Wolf, Panter, & Insko, 2011)], and approach and avoidance measures [the BIS/BAS scales as measures of approach or avoidant behaviors (Carver & White, 1994)] are also completed along with The NEO Five-Factor inventory (Costa & McCrae, 1992).

Following the battery of questionnaires, an eligibility screening is completed to ensure both participant safety and data integrity. Specifically, participants indicated if they are non-native English speakers, pregnant, have pre-existing heart conditions, a pacemaker, a BMI above 33, and/or a had a history of mental health conditions, such as anxiety disorders. If they indicate "yes" on any of these, they are ineligible to continue. Additionally, females with irregular menstruation cycles were ineligible for Session 2 due to the hormone measures (not discussed further). If all eligibility requirements were met, participants were recruited for participation in Session 2. Male participants were scheduled based on availability and time slots for the session while female participants were scheduled between 7-10 days after the start of their following menstruation cycle.

Session 2. Following session 1, participants complete a second experimental session wherein our target hypotheses are tested. We manipulate core affect and concept knowledge by having participants provide physiological measures, a brief encounter with a fake participant and a series of self-report behavioral measures). Here, five research assistants, each responsible for a different role, were involved in the experimental portion of the study. The "experimenter" had the most interaction with the participant, guiding him/her in completing the experimental tasks. The "operator" controlled setup and handling of physiological equipment and led the manipulation component of the session (see Part 3). The "confederate" was only present during

the manipulation. Lastly, two interviewers directed the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993). Following the TSST, a series of behavioral measures are gathered for information on the participant's perceptions of the task and their emotional state.

Part 1: Intake screening. Before beginning the experimental tasks, participants completed an initial screening given by the experimenter. This screening confirms participants eligibility to participate following adherence to instructions provided the day before and to document any factors that could affect physiological data. For instance, if the participant had consumed/used any caffeine, alcohol, nicotine, toothpaste, and/or yogurt or exercised within two hours before the start of the session, they were rescheduled for Session 2 completion. Likewise, if the participant was female and her menstruation had not started 7-10 days before the session, she was rescheduled. The screening also noted if the participant had heard any information relating to the study prior to their participation or did any airline travel in the three preceding days before the session.

Part 2: Physiological baseline. Following the initial screening, the experimenter attached physiological equipment to the participant measuring electrocardiography (ECG), a blood pressure arm and finger cuff which reported measures through the Continuous Non-Invasive Arterial Pressure Device (CNAP), and additional sensors for cardiac impedance. All physiological measures are gathered with a Mindware BioNex 8-channel chassis. Based on previously established research models for physiological data collection, the participant sat for a quiet 5-minute period for baseline measurements. Following this, they provided a 1 mL saliva sample for hormone measures.

Part 3: Manipulation. Once the saliva sample was collected, the participant was presented with an affect grid consisting of two dimensions: the pleasantness/unpleasantness

dimension and the arousal dimension. The experimenter then asked the participant to mark the box best representative of their current affective state. This measure importantly does not use any emotion concept words. Just as the experimenter is about to move on to the following task, the operator knocked and opened the door and told the experimenter that a previous participant (who was actually the confederate) had not been paid for participating in the study a week ago. Following deliberation, the experimenter and the operator left the room to obtain "payment," and the experimenter asked the confederate to have a seat in the room with the participant. During this phase, the confederate delivered the manipulation in a conversational manner. In the *anger* condition, the confederate stated, "I probably shouldn't tell you this, but I did this study last week, and it made me, like, pretty mad." This condition will be referred to as the "challenge" emotion concept in the analyses. In the *embarrassment* condition, the confederate used the same informal phrasing but used "embarrassed" instead of "mad." This condition will be referred to as the "threat" emotion concept in the analyses. In the *heightened arousal* condition, the last words were replaced with "…and it made my heart beat, like, really fast." There was also a control condition in which the confederate only made light conversation with the participant and did not include any emotional or affective language. Following the manipulation, the experimenter entered the room with the cash, "payed" the confederate, and the confederate exited the room. The experimenter then asked the participant to complete another affect grid, claiming that the first one could not be used since they had been interrupted. The second grid was, in actuality, given to ensure that the manipulation had no immediate effect on the participant's emotional state; that is, the participant would ideally mark in the same location that they had marked on the first grid.

***Part 4: TSST and recovery*.** The participant was then introduced to the two interviewers who would carry out the TSST. Following the established TSST model, the participant was told that they would be responsible for giving a speech about a desirable job in an area of interest (Kirschbaum, Pirke, & Hellhammer, 1993). They were then given a two-minute preparation period, wherein they prepared mentally. The interviewers then entered the room and led a 10-minute interview. If the participant could not speak for the full 10 minutes, the interviewers asked follow-up questions following multiple prompts to get them to continue. Next, a 5-minute mental arithmetic task involved counting backwards from 996 in steps of 7 was introduced to the participant. Any time a mistake was made, the participant was instructed to start again and throughout prompted to count faster. Other math tasks were available in the event that the participant found the given task too easy or too difficult. The interviewers remained neutral towards the participant throughout the 15-minute period providing no feedback other than prompting them to continue or restart if any information given was incorrect. The participant was then given a 5-minute recovery period once the TSST ended, followed by a second saliva sample. Physiological recordings were made for the preparatory, speech, math, and recovery periods separately.

Part 6: Post-questionnaires and debriefing. Following the recovery period, the participant was disconnected from the physiological equipment. They then completed follow-up questionnaires in which they rated their experience completing the study as well as the researchers involved. Of interest are the Positive and Negative Affect Scale (PANAS; Watson, Clark, & Tellegen, 1988), a Rate your Experience questionnaire, and Researcher Evaluation scale. These questionnaires were given to collect qualitative, self-report data on the emotional state of the participant as well as their attributions towards those involved as behavioral measures

for challenge and threat states, as well as general affective states. The PANAS provides a general measure of positive and negative states that the participant reports feeling. The Rate your experience questionnaire includes 15-items in which the participant rates their level of control over the task, how unexpected it was, the interviewer's role in the task and their performance, as well as their impressions of the interviewer's helpfulness, judgment. In joint, these items together provide a measure of external attributions or blame that the participant holds following the task. The Researcher Evaluation form requires the participant to provide a grade to the experimenter and two interviewers on a number of traits including: performance, respect, professionalism, enthusiasm, attire, motivation, interpersonal demeanor, helpfulness, orderliness, and overall performance. They are told that these grades are confidential and that their boss will look at it and take the grade into consideration when granting them their overall grade for being in the lab. As a reminder, I hypothesize that those in the anger condition will have more external attributions and provide harsher grades to the experimenter and interviewers than those in the embarrassed condition.

Afterwards, a funneled debriefing was given to the participant to ensure they had not predicted the role of the confederate prior to or during the manipulation. The debriefing also collected the participants' opinions on the research assistants in the study as well as the study in general. Participants were then debriefed on the session and provided with contact information for the researchers as well as the university's counseling services for stress and anxiety.

Results

Behavioral data

PANAS. To assess general affective states following the TSST between the two conditions, we computed mean reports of positive affective states and negative states from the

Positive and Negative Affective Scale (PANAS; Watson, Clark, & Tellegen, 1988). Prior to computing means, reliability analyses reveal that the positive items had a Cronbach's $\alpha = .79$. An independent samples t-test revealed no significant difference in positive states between anger ($M = 33.95$, $SE = 1.45$) and embarrassed ($M = 36.57$, $SE = 2.07$) conditions, $t(32) = -1.07$, $p = .29$. Reliability analyses also reveal that the negative items had a Cronbach's $\alpha = .86$. No significant differences were found in negative affective states between anger ($M = 21.90$, $SE = 1.48$) and embarrassed ($M = 19.36$, $SE = 1.97$) conditions, $t(32) = 1.05$, $p = .30$.

In addition to the general valence mean scores, I computed means of high arousal negative states ($\alpha = .79$; $t(32) = .56$, $p = .58$), high arousal positive states ($\alpha = .77$; $t(32) = -1.08$, $p = .29$), low arousal negative states ($\alpha = .83$; $t(32) = 1.27$, $p = .21$) and low arousal positive states ($\alpha = .67$; $t(32) = -.68$, $p = .50$). The low arousal positive states included items that could be deemed more neutral (i.e., sleepy, quiet) which could be why the reliability is so low. There were no differences between anger and embarrassed conditions for any of these states.

Rate your experience questionnaire. The Rate Your Experience Questionnaire contained 15-items asking the participant about their perceptions of the task, their performance, and the interviewers. Items indicate how much control the participants believed they had had (perceived control), how much blame they put towards the interviewers or task itself, as well as their impressions of the interviewers' behavior. All positively valenced items (e.g., "I was free to change the way the previous task went", "The interviewers were helpful") were reverse scored, so that higher numbers indicate a greater level of external attributions as deemed by more negative views of others, lack of perceived control, and more blame on others. Reliability analysis revealed a Cronbach's $\alpha = .76$ across the 15 items, indicating sufficient reliability. As

such, I am confident in computing a mean score across these items as an overall measure of external attributions.

To assess condition differences in external attributions, I conducted an independent samples t-test and found that those in the anger condition had significantly more external attributions (M = 4.13, SE = .20) than those in the embarrassed condition (M = 3.49, SE = .17), $t(32) = 2.26$, p =.03.

Researcher evaluations. All evaluation grades were transformed into numbers to calculate mean values. Higher values indicated better grades (5=A, 4=B, 3=C, 2=D, 1=E/F). As there were two interviewers, to ensure that their grades were largely similar across all items, a paired samples t-test was conducted for each item (See Table 1). Overall, there were no significant differences between grades for each interviewer except for Enthusiasm, $t(48) = -2.403$, $p = 0.02$, with Interviewer 1's rating on average being 3.5 (SE = .16) and Interviewer 2's rating on average being 3.7 (SE=.16). This may be due to the task design, in which Interviewer 1 was involved predominantly in the speech portion of the TSST providing the task and also prompting the participant to go on, more than Interviewer 2, who was predominantly in charge of handling the math task, including catching counting errors faster etc. Additionally, there may be small differences in interviewer expression, tone, and general affect during the TSST. An average was still computed of the two interviewer grades to have a single interviewer grade for each item.

A second paired-sample t-test was conducted to examine the difference between experimenter and interviewer ratings, since I hypothesized that in general experimenters would be rated more positively than interviewers, as interviewers were directly implementing the TSST and were neutral in affect throughout the entirety of their interactions. Indeed, I find that across

the entire sample, experimenters are rated more positively. For all t-tests and mean values, see Table 2 and Figure 1. As expected, experimenters were rated more positively for Respect, Enthusiasm, Motivation, Interpersonal demeanor, Helpfulness and their Overall grade. Interviewers were rated marginally more professional, which could be due to the task roles.

To assess the difference in grades between conditions among experimenter ratings and interviewer ratings, a series of independent-sample t-tests were run. I briefly describe significant differences and expected non-significant differences below.

Experimenter ratings. When looking at experimenter ratings only, a series of independent sample t-tests were conducted comparing grades per item between conditions (see Table 3 and Figure 2). In the motivation criteria, those in the anger condition (M=4.65, SE=0.11) graded more harshly than those in the embarrassed condition (M=5, SE=0), t(19)=-3.20, p=0.005. Similarly, for the interpersonal demeanor criteria, those in the anger condition (M=4.4, SE=0.15) graded more harshly than those in the embarrassed condition (M=4.93, SE=0.07), t(26.4)=-3.14, p=0.004. Importantly, the overall grade from those in the anger condition (M=4.8, SE=0.09) was lower than the grade from the embarrassed (M=5, SE=0), t(19)=-2.18, p=0.04. As expected, there were no differences in attire.

Interviewer ratings. When looking at interviewer ratings only, a series of independent samples t-tests were conducted comparing grades per item between conditions (see Table 4 and Figure 3). In the enthusiasm criteria, participants in the anger condition (M=3.38, SE=0.23) gave lower grades to the interviewers than participants in the embarrassed condition (M=3.93, SE=0.22), t(32)=-1.70, p=0.09, although this is marginal. In the motivation criteria, participants in the anger condition (M=4.25, SE=0.20) gave lower grades than those in the embarrassed condition (M=4.82, SE=0.09), t(27.1)=-2.55, p=0.02. The same pattern occurred for the

interpersonal demeanor criteria, with average lower ratings from the anger condition (M=3.75, SE=0.23) than from the embarrassed condition (M=4.50, SE=0.14), t(29.72)=-2.81, p=0.009. Just as with the experimenter ratings, the overall grade from the anger condition (M=4.28, SE=0.16) was also lower than the overall grade from the embarrassed condition (M=4.89, SE=0.08), t(19) = -0.218, p = 0.002. As expected, there were no differences in attire and professionalism.

Physiological data

Electrocardiography data was cleaned and scored (using Biolab Mindware 3.0.21) in 60-second intervals for baseline, the TSST-prep, TSST-speech, TSST-math and recovery periods, providing minute by minute heart rate. Since we also collected impedance cardiography, Mindware is also able to calculate respiratory sinus arrythmia (RSA).[2] As my research questions pertain to differing physiological profiles as a consequence of concept priming, a series of independent sample t-tests were then run through SPSS assessing the difference in heart rate and RSA between conditions.

Mean differences in TSST. First, comparisons of overall average heart rates (Table 5) and RSA (Table 6) during baseline, TSST-prep, TSST-speech, TSST-math and recovery between conditions were made, in a series of independent samples t-tests. There were no significant differences in mean heart rate nor RSA between anger and embarrassed conditions during any portion of the task. However, when looking at the values average heart rates for the anger condition were slightly higher than those in the embarrassment condition, but not by a statistically significant amount. RSA across both anger and embarrassment conditions were similar for each section.

[2] Note that impedance cardiography of the participants was not cleaned/scored, thus we relied on Mindware's automated scoring for these. Therefore, it is possible that there is some variability in the actual RSA scores than what is calculated. However, we believe that the error is negligible for these analyses.

Reactivity. As the task includes a negative affect induction, I expected to see increases in cardiovascular activity throughout all conditions. However, as a consequence of concept priming, I specifically hypothesized that the magnitude of reactivity that individuals experience will differ by condition, specifically those in the anger condition will have faster reactivity and those in the embarrassed condition will slower reactivity. To assess this, reactivity scores for both heart rate and RSA were calculated and examined in two ways. The first, Reactivity A, calculated reactivity by subtracting the mean baseline heart rate and RSA from the mean of each segment of the TSST, resulting in three reactivity scores, TSST Prep - Baseline, TSST Speech – Baseline, and TSST math – Baseline. An additional reactivity score was calculated by collapsing across all TSST periods and looking at Entire TSST – Baseline. The second, Reactivity B, was calculated by subtracting the last minute of baseline from the first minute of each part of the TSST, resulting in three reactivity scores: First Minute Prep – Last Minute Baseline, First Minute Speech – Last Minute Baseline, and First Minute Math – Last Minute Baseline. Reactivity scores were calculated both ways as both calculations of reactivity scores have been used in the literature (Allen, Mendes, & Blascovich, 2001).

Reactivity A. For all independent sample t-tests for Reactivity A, see Tables 8-9. For heart rate, there was a larger change in Reactivity A for those in the embarrassed condition (M=11.8, SE=2.3) compared to those in the anger condition (M=5.6, SE=1.7) during the preparation period, t(26.2)=-2.09, p=0.04. Those in the embarrassed condition (M=15.1, SE=2.9) had a marginally larger change in heart rate from baseline during the speech task compared those in the anger condition (M=9.6, SE=1.7), t(32)=-1.736, p=0.09. No significant differences were found in reactivity during the math portion. When collapsing across all portions of the TSST,

there were no significant differences between condition in reactivity. There were no significant differences between conditions in reactivity in RSA (see Table 8).

Reactivity B. For all independent sample t-tests for Reactivity B, see Tables 9-10. Those in the embarrassed condition (M=9.9, SE=2.2) had marginally more reactivity compared to those in the anger condition (M=5.8, SE=1.3) during the preparation period, $t(32)$=-1.7, p=0.10. There were no other differences between conditions in heart rate reactivity or RSA reactivity.

Recovery. To assess differences in recovery time, I followed the method used by Allen, Blascovich and Mendes (2001). Here, the last minute of baseline heart rate is subtracted from the first minute of recovery heart rate. This value is then divided by 2 to obtain a threshold in which the heart rate is half of the total increase. Then, looking at 20-second intervals of the recovery period, I identified when the participant's heart rate was at this threshold above their baseline. For example, if an individual's first minute of recovery heart rate was 96 and their heart rate at the last minute of baseline was 72, the threshold would be 12 ((96-72)/2). Then, I would identify the time interval during recovery in which the participant's heart rate was 84 or lower.

However, when calculating these values, I found that most of the participants had difference values that were negative (meaning they were already at the heart rate and RSA levels that were experienced by the last minute of their baseline). This likely occurred due to habituation following the 15-minute TSST, i.e. participants grew acclimated to the environment and reached baseline rates faster than expected. Only 12 participants had a difference score that was great than 0 and not negative, ranging from .65-13.36. As these values are small, I opted not to explore the recovery aspect of my hypothesis as it will likely require more advanced statistical methods.

Discussion

The relationships between attributions and perception of a challenge or threat state were generally supported by the self-report data. I hypothesized that those primed with a concept of anger would report more external attributions (as seen through perceived control and blame), corresponding with a challenge state. Indeed, based on results from both the Rate Your Experience questionnaire and Research Evaluations, participants in the anger condition made more external attributions for their performance.

The physiological data failed to support my hypotheses, which may be in part due to the small sample size. However, when looking at the means of reactivity, there are beginning signs of the expected trends. The Biopsychosocial Model predicts increased cardiovascular activity for perceptions of a challenge state (Blascovich & Mendes, 2010). This trend was observed in participants primed with the anger condition, but it did not significantly differ from those in the embarrassed condition. Another potential explanation for the lack of statistical findings with the physiological data comes from the TCE and the manipulation design. Although participants primed with concept knowledge of anger were ideally supposed to construct a challenge emotion state and participants primed with embarrassment were supposed to construct a threat emotion state, the primes may have led to unexpected emotional states and thus varying physiological responses. This actually aligns with the TCE which suggests that individuals can interpret situations differently, as well as emotion concepts differently. As such, the manipulation may have led to varied emotion constructions dependent upon the individual's own past experiences and associated physiological responses (Barrett, 2014). Also, participants may not have constructed an emotion aligned to either one of these constructs if they were unphased by the manipulation, or, based on past experiences, have different perceptions of speech and mental

arithmetic in general – for example, some reported that they love performing in front of others. Future analyses should include responses on the funneled debriefing to see the extent to which the manipulation impacted participants' conceptual knowledge about the TSST.

In regard to the lack of any differences in RSA reactivity, and values being similar across the anger and embarrassment conditions, it is possible that challenge and threat states induce similar vagal responses, since both are correlated with increased levels of stress. As such, future analyses should include the control conditions to compare the relative reactivity between all conditions.

Finally, we were unable to analyze the time to recovery, thus preventing us from arriving to conclusions about resiliency, vulnerability, and their relationship to challenge and threat perceptions. Many of the participants had already returned to baseline levels of heart rate and RSA. This could be due to habituation. That is, by the first minute of recovery, participants had acclimated to the study environment. This does not mean that they did not "recover," but rather return to baseline levels could have occurred earlier on in the paradigm. As recovery has important implications for adaptive and maladaptive responses to stressful situations, as well as vulnerability to anxiety disorders, it is a concept worth exploring in future studies.

Overall, even with the small sample size, the behavioral and self-report results from this study show support for the TCE and the BPS, in that participants who were primed with anger reported having more external attributions than those primed with embarrassment. This suggests an expected construction of a challenge emotion state. Physiological trends should be further researched to confirm these constructions, including systematic data collection for all components of the BPS (VC, CO, and TPR) (Blascovich & Mendes, 2010). Observable and significant trends in both self-report and physiological data could help provide vital information

about the role of the TCE in the context of perceived stress. This could have important implications for treatment processes related to emotion-based psychological disorders, such as depression and anxiety.

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Table 1.

Paired samples t-test comparing grades for Interviewers 1 and 2

	Interviewer 1 *M (SE)*	Interviewer 2 *M (SE)*	*t*	*df*	*p*
Respect	4.6 (0.09)	4.6 (0.09)	0.81	48	0.42
Professionalism	4.8 (0.06)	4.9 (0.04)	-0.81	48	0.42
Enthusiasm	3.5 (0.16)	3.7 (0.16)	-2.40	48	*0.02
Attire	4.8 (0.08)	4.8 (0.09)	1.00	48	0.32
Motivation	4.4 (0.93)	4.4 (0.12)	-1.13	48	0.26
Interpersonal demeanor	3.9 (0.14)	4.0 (0.15)	-1.95	48	0.06
Helpfulness	3.9 (0.15)	4.0 (0.15)	-1.35	48	0.18
Orderliness	4.8 (0.07)	4.8 (0.09)	0.57	48	0.57
Overall	4.5 (0.11)	4.4 (0.13)	-0.81	48	0.42
Overall (Compared to research assistants)	4.5 (0.11)	4.4 (0.13)	0.44	39	0.67

Note. *****Denotes when Levene's Test for Equality of Variances revealed that equal variances were not assumed, so df and t-statistic are adjusted.

Table 2.

Paired samples t-test comparing experimenter and interviewer ratings within individuals.

	Experimenter *M (SE)*	Interviewers Combined *M (SE)*	*t*	*df*	*p*
Performance	4.8 (0.05)	4.6 (0.11)	2.22	45	0.03
Respect	5.0 (0.00)	4.6 (0.09)	4.11	45	< .001
Professionalism	4.8 (0.06)	4.9 (0.04)	-1.03	45	0.31
Enthusiasm	4.6 (0.10)	3.6 (0.16)	5.97	45	< .001
Attire	4.7 (0.08)	4.7 (0.09)	-0.12	45	0.91
Motivation	4.8 (0.05)	4.4 (0.13)	3.27	45	< .001
Interpersonal demeanor	4.7 (0.09)	3.9 (0.15)	5.19	45	< .001
Helpfulness	4.8 (0.07)	3.9 (0.15)	5.63	45	< .001
Orderliness	4.8 (0.06)	4.8 (0.07)	-0.14	45	0.89
Overall	4.9 (0.04)	4.4 (0.12)	4.12	45	< .001

Figure 1.

Means for experimenter and interviewer grades across conditions.

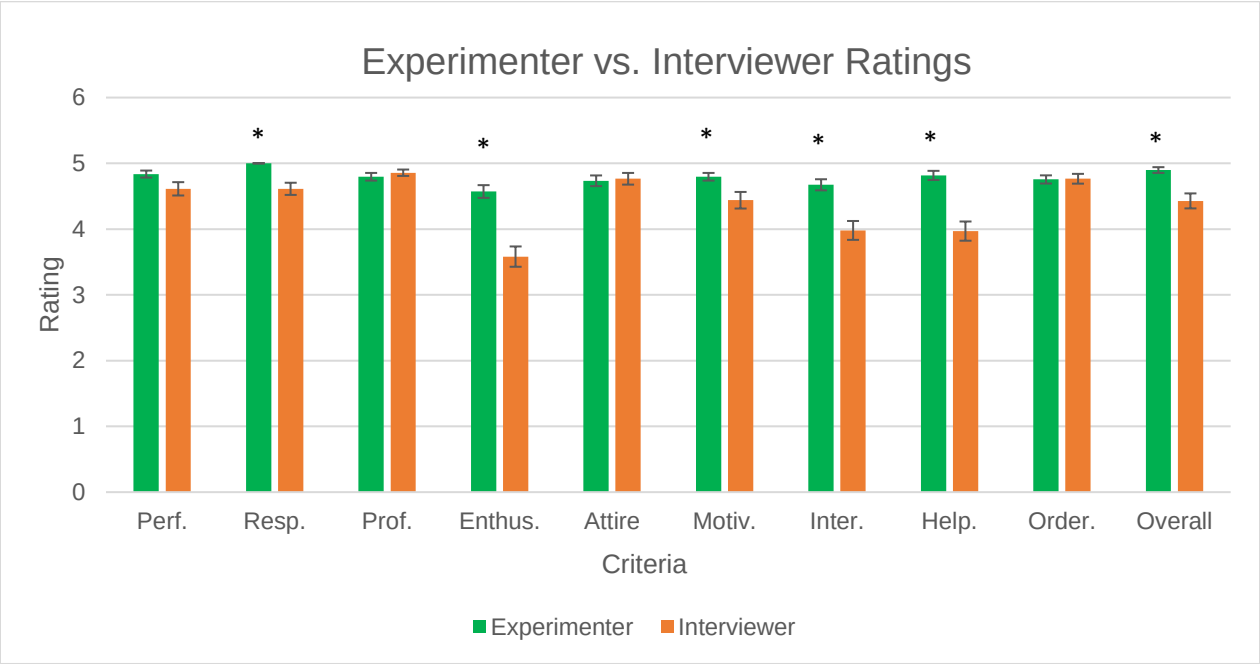


Table 3.

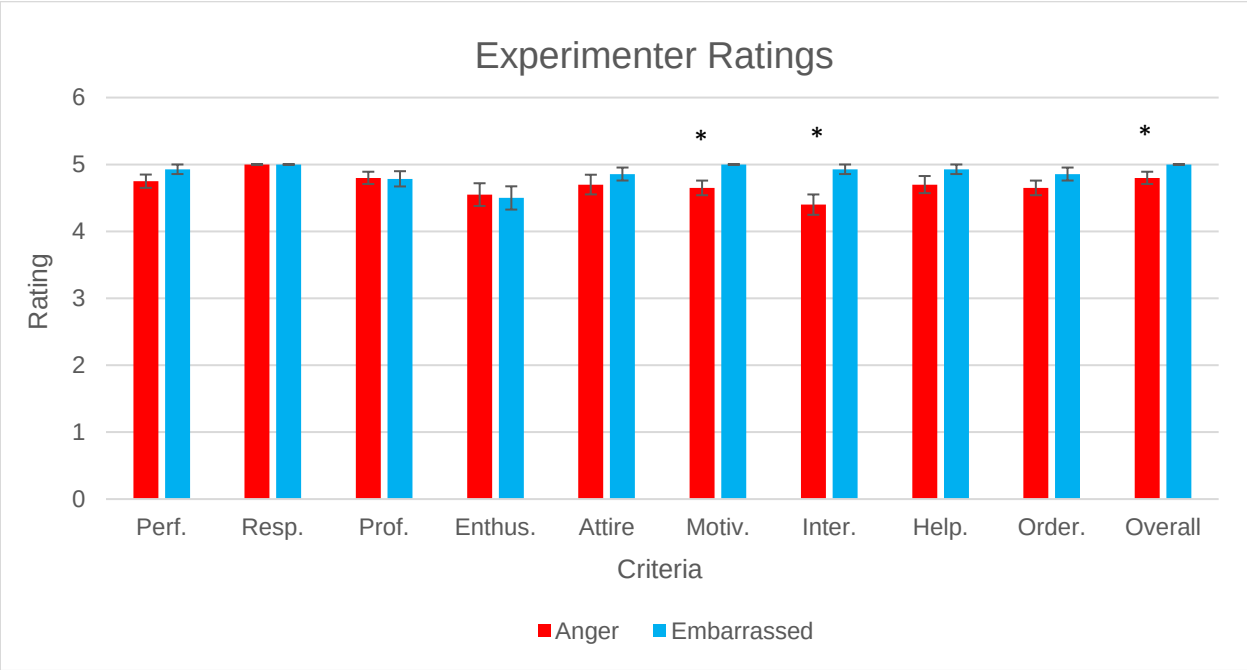
Independent samples t-tests comparing experimenter grades between conditions.

	Anger *M (SE)*	Embarrassed *M (SE)*	*t*	*df*	*p*
Performance	4.75 (0.09)	4.93 (0.07)	-1.34	32	0.19
Respect	5.00 (0.00)	5.00 (0.00)	-	-	-
Professionalism	4.80 (0.09)	4.79 (0.11)	0.098	32	0.92
Enthusiasm	4.55 (0.17)	4.50 (0.17)	0.2	32	0.84
Attire	4.70 (0.15)	4.89 (0.09)	-0.18	32	0.42
Motivation	4.65 (0.11)	5.00 (0.00)	-3.20	19	*0.005
Interpersonal demeanor	4.40 (0.15)	4.93 (0.07)	-3.14	26.4	*0.004
Helpfulness	4.70 (0.13)	4.93 (0.27)	-1.39	32	0.13
Orderliness	4.65 (0.11)	4.86 (0.09)	-1.34	32	0.17
Overall	4.80 (0.09)	5.00 (0.00)	-2.18	19	*0.04

*****Denotes when Levene's Test for Equality of Variances revealed that equal variances were not assumed, so df and t-statistic are adjusted.

Figure 2.

Mean Experimenter Ratings in Anger and Embarrassed Conditions



*Denotes statistically significant differences ($p < 0.05$).

Table 4.

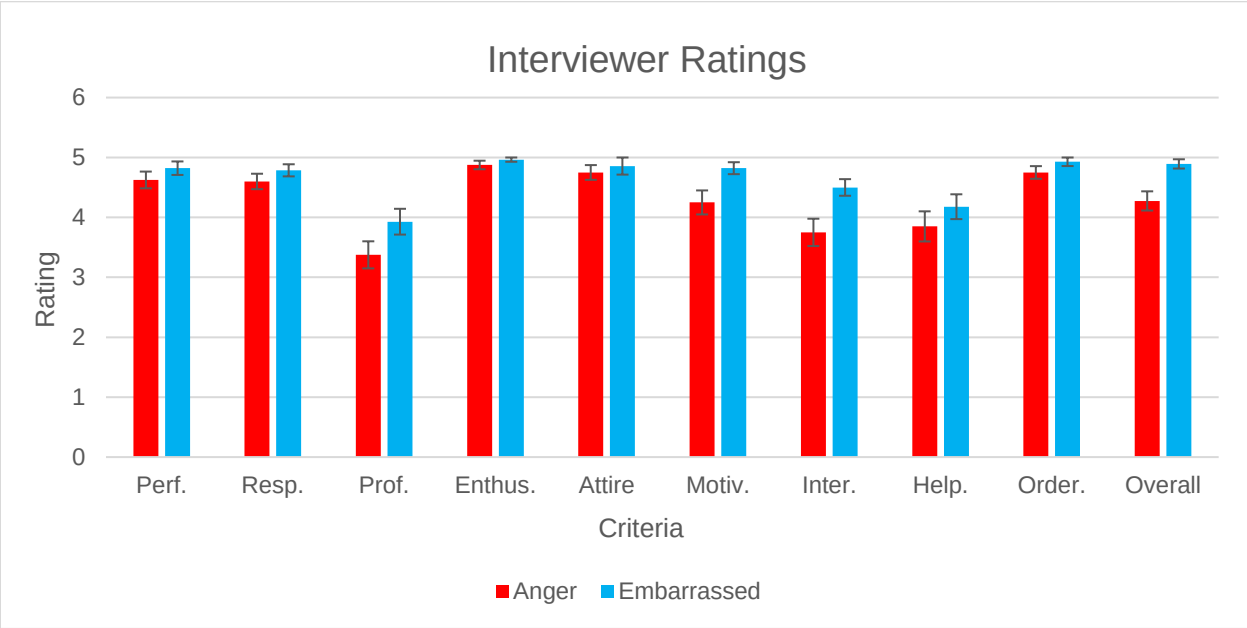
Independent samples t-test comparing interviewer grades between conditions

	Anger *M (SE)*	Embarrassed *M (SE)*	*t*	*df*	*p*
Performance	4.63 (0.14)	4.82 (0.11)	-1.02	32	0.32
Respect	4.60 (0.13)	4.79 (0.10)	-1.06	32	0.29
Professionalism	4.88 (0.07)	4.96 (0.04)	-0.98	32	0.332
Enthusiasm	3.38 (0.23)	3.93 (0.22)	-1.70	32	0.09
Attire	4.75 (0.12)	4.86 (0.14)	-0.57	32	0.58
Motivation	4.25 (0.20)	4.82 (0.09)	-2.55	27.1	*0.02
Interpersonal demeanor	3.75 (0.23)	4.50 (0.14)	-2.81	29.7	*0.009
Helpfulness	3.85 (0.25)	4.18 (0.27)	0.95	32	0.36
Orderliness	4.75 (0.11)	4.93 (0.07)	-1.27	32	0.21
Overall	4.28 (0.16)	4.89 (0.08)	-3.48	26.8	*0.002

*****Denotes when Levene's Test for Equality of Variances revealed that equal variances were not assumed, so df and t-statistic are adjusted.

Figure 3.

Mean Interviewer Ratings in Anger and Embarrassed Conditions



*Denotes statistically significant differences ($p < 0.05$).

Table 5.

Independent samples t-test of mean heart rate for each TSST section between conditions.

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Baseline	77 (2.2)	72 (2.9)	1.53	32	0.13
Prep	83 (2.1)	83 (3.7)	-0.13	32	0.90
Speech	87 (2.0)	87 (4.6)	-0.003	32	0.99
Math	87 (2.0)	81 (3.9)	1.32	32	0.20
Recovery	75 (2.2)	72 (2.4)	0.71	32	0.48

Table 6.

Independent samples t-test of mean RSA for each TSST section between conditions.

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Baseline	6.5 (0.24)	6.5 (0.23)	0.07	32	0.95
Prep	6.7 (0.24)	6.5 (0.33)	0.66	32	0.51
Speech	6.8 (0.22)	6.5 (0.33)	0.77	32	0.48
Math	6.8 (0.23)	6.7 (0.27)	0.27	32	0.79
Recovery	7.0 (0.22)	7.0 (0.29)	-0.14	32	0.89

Table 7.

Independent samples t-test of heart rate Reactivity A (mean for each section – mean baseline).

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Prep-Baseline	5.8 (1.7)	11.8 (2.3)	-2.09	26.2	*0.04
Speech-Baseline	9.6 (1.7)	15.1 (2.9)	-1.77	32	0.09
Math-Baseline	9.6 (1.5)	9.8 (2.0)	-0.07	32	0.95
Entire TSST - Baseline	9.2 (1.5)	13.1 (9.3)	-1.44	32	0.16

*****Denotes when Levene's Test for Equality of Variances revealed that equal variances were not assumed, so df and t-statistic are adjusted.

Table 8.

Independent samples t-test of RSA Reactivity A (mean for each section – mean baseline).

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Prep-Baseline	0.23 (0.13)	-0.02 (0.28)	0.86	32	0.40
Speech-Baseline	0.25 (0.17)	0.75 (0.27)	0.81	32	0.43
Math-Baseline	0.24 (0.22)	0.17 (0.21)	0.22	32	0.82
Entire TSST-Baseline	0.24 (0.17)	0.05 (0.24)	0.66	32	0.51

Table 9.

Independent samples t-test of heart rate Reactivity B (first minute of each section – last minute of baseline).

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Prep-Baseline	5.8 (1.3)	9.9 (2.2)	-1.69	32	0.10
Speech-Baseline	19.4 (2.5)	24.4 (4.1)	-1.11	32	0.28
Math-Baseline	13.2 (1.9)	11.0 (2.9)	0.65	32	0.52

Table 10.

Independent samples t-test of RSA Reactivity B (first minute of each section – last minute of baseline).

Section	Anger	Embarrassment	*t*	*df*	*p*
	M (SE)	*M (SE)*			
Prep-Baseline	0.27 (0.21)	9.9 (0.30)	0.49	31	0.63
Speech-Baseline	-0.23 (0.25)	24.4 (0.54)	-0.14	32	0.89
Math-Baseline	0.12 (0.22)	11.0 (0.27)	-0.39	32	0.69