Emotion Regulation Under Pressure: The Impact of Cognitive Reappraisal and Expressive Suppression on Stress Responses

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Abstract

Acute social stress, a common type of stress faced in situations of intense pressure and social evaluation, induces both psychological and physiological responses. When these responses are prolonged or poorly managed, they can have detrimental effects on one's health. Emotion regulation, the capacity to control and modulate one's emotional responses, is a central mechanism that shapes how individuals experience and recover from stressors. This study examined how two prevalent emotion regulation strategies, cognitive reappraisal (CR) and expressive suppression (ES), influence acute social stress responses. Participants (N=58) completed the Emotion Regulation Questionnaire as part of an online survey to assess their use of each strategy. They then participated in the Trier Social Stress Test (TSST) and control version of the TSST (C-TSST) in a counterbalanced design. Physiological markers (heart rate [HR], heart rate variability [HRV], and skin conductance level [SCL]), along with subjective stress ratings, were collected through both tasks. Through a manipulation check, it was concluded that the TSST successfully induced more stress than the C-TSST. Multiple linear regression analyses and linear mixed-effects models assessed associations between emotion regulation strategies and stress responses. ES was significantly associated with higher perceived threat and showed a slight trend towards slower HR recovery. CR was not found to be significantly linked to physiological or subjective stress markers, although slight trends were present. These findings highlight the potential impact of emotion regulation on stress reactivity. By gaining a deeper understanding of adaptive and maladaptive emotion regulation strategies, interventions that promote healthier coping mechanisms can be implemented.

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Introduction

Stress is a common part of modern life, with individuals experiencing stressors in nearly every aspect of their daily routines (Zawadzki et al., 2019). While managing stress is crucial for maintaining mental and physical health, there are individual variations in regulating emotional responses to stressors (Herr et al., 2018; Rachmad, 2022). These variations influence overall resilience and well-being (Franklin et al., 2012; Rosenberg et al., 2015). Due to the significant impact of stress, research has increasingly focused on the role of emotion regulation strategies in modulating physiological and psychological stress responses (Flores-Kanter et al., 2021; Rosenbaum et al., 2022; Wang & Saudino, 2011). Among these strategies, cognitive reappraisal (CR)—a strategy that involves reframing stressful situations—and expressive suppression (ES)—a strategy that involves the inhibition of emotional expressions—are widely studied approaches that impact stress outcomes differently (Cutuli, 2014; Gross & John, 2003).

The current study investigated how these prevalent emotion regulation strategies influenced psychological and physiological markers of stress. Specifically, it examined whether CR led to more adaptive stress responses than ES (Gross & John, 2003). Participants completed the Trier Social Stress Test (TSST), a well-established paradigm designed to induce acute social stress, alongside a low-stress control condition (C-TSST). This dual-condition study design allowed for a unique examination of how emotion regulation strategies impact individual stress responses and offers valuable insights into effective stress management techniques.

Stress

Hans Selye defines stress as "the non-specific response of the body to any demand for change" (Selye, 1978). It is the body's physical, mental, and emotional response to a perceived stressor—a stimulus that triggers a stress response—and strains one's ability to cope effectively

(American Psychological Association, 2018b; 2018c). According to Selye, the body reacts to all demands (i.e., physical, emotional, psychological) with a similar physiological response (Ramanathan & Desrouleaux, 2022). This automatic response includes increased heart rate (HR), hormone release (i.e., cortisol), and heightened awareness (Ramanathan & Desrouleaux, 2022). However, individuals differ in how intensely they experience these reactions—a concept known as stress reactivity (Kiecolt-Glasset et al., 2020). Stress reactivity refers to how strongly an individual responds to a stressor (Kiecolt-Glasset et al., 2020). Some have high stress reactivity, meaning their body reacts more intensely or takes longer to return to baseline; others have lower reactivity, indicating more resilience to stressors (Cohen & Manuk, 1995).

As an inevitable aspect of human life, stress influences both psychological and physiological functioning (Hubbard et al., 2018; Schulz et al., 2021). It occurs when individuals feel unable to cope with external pressures and often triggers a cascade of physical and emotional reactions (Böke et al., 2019; Chu et al., 2024; Myslivecek, 2015). Stress impacts various domains of individual life, including work, education, social interactions, and overall well-being (Franklin et al., 2012; Zawadzki et al., 2019). While short-term stress can sometimes be helpful, called eustress (e.g., enhances focus and motivation), long-term or excessive stress, often referred to as distress, takes a toll on mental and physical health (Chu et al., 2024; Degroote et al., 2020). Chronic exposure to stressors and lack of effective strategies contributes to the exacerbation of pre-existing mental health issues, cardiovascular disease, and can result in weakened immune systems (Chu et al., 2024; Cohen et al., 2007; Garfin et al., 2018).

Given stress's widespread implications, research on its impact continues to evolve (Schulz et al., 2021; Smith & Perez, 2018). Existing studies have made significant strides in identifying the physiological and psychological mechanisms underlying stress responses

(Hatunoglu, 2020; Smith & Perez, 2018). While individual variations in stress reactivity are observed, the general responses are well-established. These reactions are highlighted in the upcoming section.

Stress Response

Stress has long been studied by researchers, resulting in many theories around its mechanisms (Ghasemi et al., 2024). For the purpose of this study, these theories can be broadly divided into two main dimensions: physiological models and psychological models. Physiological theories emphasize the body’s biological responses to stress, while psychological theories focus on cognitive and emotional processes involved with stress perception and regulation (Smith & Perez, 2018). Understanding both aspects is essential to gain a comprehensive view of how stress impacts individuals.

Physiological Stress Responses

Stress has been demonstrated to trigger automatic reactions to help the body respond to perceived threats (Arza et al.,2019; Myslivecek, 2015). These reactions are primarily regulated by the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis (Dahlman et al., 2021; Schuurmans et al., 2021). Both of these systems work together to regulate individual stress responses (Rotenberg & McGrath, 2016).

The ANS consists of two branches that regulate different responses to stress (Oubaid, 2023; Pareira et al., 2017). The sympathetic nervous system (SNS)—which becomes active during stressful situations—is responsible for the body’s fight-or-flight response (Jarczok et al., 2020; McCarty, 2016b). It prepares an individual to take necessary action by increasing HR, breathing rate, skin conductance, and dilating the pupils. The second branch of the ANS—the parasympathetic nervous system (PNS)—promotes relaxation and recovery (Pareira et al., 2017).

By guiding the rest-and-digest response, the PNS allows our body to restore balance after a stressful condition, counteracting the SNS (Jarczok et al., 2020). Each branch of the ANS becomes active at different time points during a stressor (Yulbarsovna, 2025). The SNS is the initial response to prepare the body for action, while the PNS steps in later to restore the body to a calm, balanced state, known as PNS rebound (Lehrer, 2021). Prolonged activation of the ANS, particularly the SNS branch, can lead to chronic stress, a condition that is associated with various health problems (Yulbarsovna, 2025).

The other neural system that regulates stress responses, the HPA axis, involves the coordination of the hypothalamus, pituitary gland, and adrenal glands (Joseph & Whirledge, 2017; Micale & Drago, 2018). These structures work together to regulate the release of stress hormones in response to a stressful situation (Micale & Drago, 2018). In this chain reaction, the hypothalamus first releases corticotropic-releasing hormone, stimulating the pituitary to release adrenocorticotropic hormone, which then stimulates the adrenal glands to release cortisol (Leistner & Menke, 2020). This hormone, in turn, helps the body deal with increasing stress levels. Prolonged activation or high levels of cortisol in the blood can lead to immune system suppression, resulting in chronic health issues (McGregor et al., 2016; Weber et al., 2022).

Hans Selye’s (1950) General Adaptation Syndrome (GAS) is one of the foundational theories explaining the biological stress response. This theory describes stress as a three-stage process. First, there is the alarm stage, during which our body detects the stressors and activates the nervous system (McCarty, 2016a). This stage is followed by the resistance stage, where the body tries to adapt to prolonged stress. Lastly, there is the exhaustion stage, where exposure to chronic stress depletes resources, potentially resulting in burnout (Buckner et al., 2017).

Researchers often collect physiological markers of stress to understand how well an individual can regulate their response (Pascoe et al., 2017). These markers include HR, heart rate variability (HRV), and skin conductance response (SCR). Both HR (measured in beats per minute) and SCR—assessed through skin conductance level (SCL)—increase during a stressful condition due to SNS activation. Afterwards, the PNS response allows for a return to baseline levels (Eisenbarth et al., 2016). Similarly, a higher HRV value is typically linked to better stress regulation (Mackersie & Calderon-Moultrie, 2016). These physiological markers can provide insight into how quickly individuals recover from stressful conditions.

Psychological Stress Responses

While the body has automatic physiological reactions to stress, the way individuals perceive stressors varies significantly, impacting overall well-being (Franklin et al., 2012; Rachmad, 2022). Selye's theory explains the biological response, but Lazarus and Folkman's (1984) Transactional Model of Stress emphasizes the psychological response. This model suggests that stress also involves a cognitive experience that is shaped by perceptions of the situation (Kivak, 2020). First, individuals conduct the primary appraisal, assessing if the situation is a threat, a challenge, or irrelevant (Velichkovsky, 2009). If they conclude that the situation poses a threat, they continue with the secondary appraisal (Castro et al., 2022). At this stage, they determine their ability to cope with the stressor (Castro et al., 2022). Based on this assessment, some view stressors as manageable while others can experience distress and become overwhelmed, leading to variations in their responses to stress (Castro et al., 2022; Ferrer et al., 2021).

The psychological experience is shaped by one's perception, emotions, and cognitive processes. Some individuals remain resilient in the face of stress while others experience anxiety and emotional distress (Biggs et al., 2017). Cognitive appraisal, a process by which individuals evaluate the stressful situation, plays a role in psychological responses (Biggs et al., 2017). Evaluating a stressor as overwhelming or beyond one's control leads to feelings of anxiety. On the other hand, viewing it as something they can handle allows individuals to cope more effectively.

Expanding on Lazarus and Folkman's Transactional Model of Stress, the Biopsychosocial Model of Challenge and Threat explains how individuals respond to situations based on perceived resources (Schwerdtfeger et al., 2021). In high-pressure situations, individuals assess if they have the skills to handle it and how difficult the task is (Uphill et al., 2019). Depending on their evaluation, people can be in a challenge or a threat state. Challenge appraisal occurs when perceived resources exceed the demands of the task, resulting in the individual believing they can handle the situation (Schwerdtfeger et al., 2021). This idea is associated with confidence in their abilities and a lower stress response. However, threat appraisal ensues when perceived demands exceed the resources present to handle the situation. This perception results in feeling unprepared, increased anxiety, and greater stress response (Schwerdtfeger et al., 2021). This model helps explain why some individuals often thrive under pressure while others struggle.

These individual variations can also be partially explained by the different coping strategies people employ to handle stress (Biggs et al., 2017). One prominent strategy highlighted by Folkman and Lazarus (2013) is problem-focused coping (PFC). PFC is a proactive strategy that involves making a plan to directly address the stressor one is facing. For example, when facing a difficult situation at work, an individual employing PFC could address the issue by increasing communication with supervisors, talking to coworkers, and making a schedule to determine how to proceed. An alternative strategy is emotion-focused coping (EFC). EFC involves the regulation of emotions stemming from the stressor (Biggs et al., 2017). This strategy consists of various techniques aimed at managing stress. Some are maladaptive and associated with adverse outcomes (Biggs et al., 2017). For example, a student with many upcoming deadlines might cope by binge-watching TV to avoid thinking about it altogether. On the other hand, there are other strategies that can help individuals control their emotions to effectively cope with a stressor. For instance, some people use constructive emotional processing, such as journaling or meditation, to calm themselves down. PFC and EFC are not mutually exclusive strategies (Biggs et al., 2017). In fact, individuals often use both strategies simultaneously when managing stressors in various areas of life. Another coping strategy many rely on is the avoidance mechanism, which involves entirely ignoring or distancing oneself from the stressor (Biggs et al., 2017). Long-term application of this strategy is associated with maladaptive health outcomes. The effectiveness of coping strategies varies across individuals and is influenced by other cognitive processes (Biggs et al., 2017).

Psychological responses to stress are also dependent on the type of stressor (Oken et al., 2015). Short-term stress is associated with increased anxiety, heightened emotions, and impaired concentration (Dhabhar, 2018). Long-term stress can lead to more serious mental health issues, including depression, burnout, and feelings of incapability (Bayes et al., 2021; McEwen, 2017). Being chronically stressed reinforces the use of maladaptive coping mechanisms over time, making it easier for individuals to rely on these when stressors arise (Wadsworth, 2015). This default employment happens because chronic stress can impair one's cognitive flexibility—the ability to shift thinking, adapt to new information, and modify behaviour in changing situations (American Psychological Association, 2018a; Girotti et al., 2024). When cognitive flexibility is compromised, individuals default to what is familiar since it requires less mental effort and provides short-term comfort (Knauft et al., 2021). These patterns become reinforced through habitual use, making it harder to engage in constructive strategies when under cognitive strain.

Psychological stress responses are often collected through self-report measures where individuals express their emotions at various timepoints during a condition (Franklin et al., 2012). This study employed the State-Trait Anxiety Inventory-State subscale (STAI-S) and the Stress Appraisal of Acute Stress (SAAS) scale. The STAI-S allowed participants to describe how much of a particular emotion they were feeling, while the SAAS was used to understand subjective levels of stress.

Acute Social Stress

In situations characterized by intense pressure, individuals commonly experience acute stress (i.e., a short-term response initiated by the SNS to a perceived threat; Garfin et al., 2018). It differs from chronic stress in that it typically resolves once the stressor has been removed (Garfin et al., 2018). Acute social stress, which is a form of acute stress, arises from social situations (Kupper et al., 2021). Individuals tend to desire feelings of belonging and are sensitive to social rejection (Schaan et al., 2020). Therefore, when they are placed in situations where they are being evaluated, judged, or scrutinized by others, the stress response becomes active (Schaan et al., 2020). As such, it is prevalent during job interviews and public speaking (Von Dawans et al., 2019). The reaction is typically characterized by activation of the SNS, causing the fight-or-flight response to kick in, leading to increased HR, heightened anxiety, and impaired performance (Kuhlman et al., 2023; Von Dawans et al., 2018).

Trier Social Stress Test

Developed by Kirschbaum and colleagues (1993), the Trier Social Stress Test (TSST) is a widely used protocol designed to induce acute social stress. By having participants deliver a speech and complete an arithmetic task in front of evaluators, the TSST effectively mimics real-world social stressors (Labuschagne et al., 2019). The focus on social judgement and pressure placed on the individuals activates the ANS, eliciting both a physiological (e.g., increased HR and SCR) and psychological (e.g., heightened anxiety, perceived stress) stress response (Kupper et al., 2021; Von Majewski et al., 2023). The C-TSST is a low-stress variation of the TSST, designed to compare stress responses (Het et al., 2009). It reduces social judgement and pressure by not having an evaluative component. This protocol allows for the isolation of the effect of social evaluation on individual stress levels. Using the TSST and C-TSST paradigms allows researchers to assess for acute stress responses in a controlled environment. They offer valuable information on how individuals react to socially demanding situations, advancing our understanding of the stress response, which is essential in developing effective interventions.

Emotion Regulation

Emotion regulation, the ability to control and modulate one’s emotional responses, has emerged as a central mechanism that shapes how individuals experience and recover from stressors (Gross, 1998). It involves managing emotional reactions in order to maintain psychological well-being and effective functioning (Verzeletti et al., 2016). Some emotion regulation strategies (ERS) are adaptive, whereby they help individuals regulate emotions effectively (Cutuli, 2014). Others can be maladaptive, resulting in prolonged distress (Aldao et al., 2014).

Gross's Process Model (1999) is one of the most influential frameworks for understanding emotion regulation. It identifies five different stages in which emotional regulation can occur: situation selection, situation modification, attentional deployment, cognitive change, and response modulation (Gross, 2015). Situation selection refers to choosing environments that influence emotional exposure. This stage could include seeking out situations that evoke desired behaviours or avoiding ones that result in unwanted emotions. Situation modification involves altering aspects of a situation to change the emotional impact it has on the individual. Attentional deployment refers to directing focus away from or toward different aspects of a situation to change the emotional impact. Cognitive change involves reinterpreting the meaning of a situation, often through reappraisal, to alter the emotional impact. Lastly, response modulation focuses on suppressing or controlling outward emotional expressions.

The two central emotion regulation strategies of Gross's Process Model are cognitive reappraisal (CR) and expressive suppression (ES). Both represent distinct points in the emotion regulation timeline. CR occurs early in the process as a form of cognitive change, while ES is a response modulation strategy focused on inhibition (Gross, 2015). These two strategies fall under EFC, with CR being a constructive technique and ES being associated with adverse outcomes (Biggs et al., 2017).

Cognitive Reappraisal

CR is an adaptive strategy that involves reframing the interpretation of a stressor to reduce its emotional impact (Volkaert et al., 2020). Rather than dwelling on negative emotions, individuals employing this strategy decide to alter their perception of the event (Dryman & Heimberg, 2018). Altering the interpretation of a stressor can help shift appraisal from threat to challenge, allowing the individual to view the situation as manageable (Schwerdtfeger et al., 2021). CR reduces physiological stress markers (i.e., lower SNS activation) and a faster stress recovery (i.e., faster PNS rebound; Cristea et al., 2014). This strategy also lowers levels of anxiety, promotes psychological resilience, encourages cognitive flexibility, and improves coping abilities (Riepenhausen et al., 2022).

Expressive Suppression

ES involves inhibiting outward emotional expressions and failing to address or change internal emotional experiences (Gross & John, 2003). Individuals aim to reduce the intensity of emotions by suppressing its outward presentation (Dryman & Heimberg, 2018). This strategy is often maladaptive and is associated with heightened physiological stress responses and prolonged SNS activation (Lin et al., 2015; Sikka et al., 2022). It has also been linked to greater emotional distress, rumination, and poor coping strategies (Fischer et al., 2021). While it can sometimes be useful in short-term situations, long-term use of this strategy is associated with greater anxiety, depression, and emotional exhaustion (Cameron & Overall, 2018).

Emotion Regulation Strategies and Stress Response

Emotion regulation plays a pivotal role in everyday stress management, especially under conditions of social evaluation, such as job interviews and public speaking (Jiang et al., 2022). The TSST effectively mimics such scenarios by inducing acute social stress in a controlled experimental setting (Allen et al., 2017). This method allows researchers to systematically examine how individuals regulate emotional responses under stress. A growing body of literature indicates that differences in emotion regulation strategies—particularly CR and ES—significantly influence both subjective and physiological stress responses (Riepenhausen et al., 2022; Wang & Saudino, 2011). Use of CR allows individuals to reinterpret stressors in a less threatening manner, thereby reducing the likelihood of transitioning from acute to chronic stress

(Moore et al., 2008). CR can serve as a buffer against acute stress by reducing stress levels and moderating physiological responses (Tyra et al., 2024). This strategy has consistently been associated with lower cortisol output, lower SNS activation, and faster parasympathetic rebound (Brockman et al., 2017; Fiol-Veny et al., 2019; Troy et al., 2010). In contrast, habitually inhibiting emotional expressions without altering the underlying experience through the use of ES is linked to worse stress outcomes (Butler et al., 2003; Troy et al., 2010). It can prolong SNS arousal, blunt parasympathetic rebound, and increase levels of anxiety, depression, and personal struggles (Butler et al., 2003).

However, while the relationship between these strategies and stress outcomes is well documented, few studies have investigated how CR and ES relate to real-time stress responses during socially evaluative settings (Jentsch et al., 2020; Krkovic et al., 2018). Existing research relies on trait-level assessments of emotion regulation without examining how these strategies relate to physiological and psychological stress responses. Additionally, few studies have used paradigms that specifically induce acute social stress, like the TSST, to explore how each strategy impacts individual stress reactivity. While CR has generally been linked to adaptive outcomes and ES to maladaptive ones, these findings are mostly in relation to everyday stress. However, socially evaluative situations may elicit distinct emotional and physiological responses, due to the heightened stakes and perceived judgement from others. It remains unclear whether evaluative situations result in the same emotional responses observed in general contexts. Furthermore, limited research incorporates multiple physiological stress markers (i.e., HR, HRV, SCR) alongside psychological responses (i.e., SAAS, STAI-S) to provide a comprehensive understanding of stress responses. These gaps highlight the need for studies that investigate how emotion regulation strategies interact with subjective experiences and physiological responses in socially stressful situations.

Purpose and Hypotheses

The current study was developed to address these gaps in the literature. By using the TSST to induce social stress and the C-TSST for comparison, the current study examined how CR and ES operate under conditions of acute social stress. This study is unique in that it collected not only psychological stress markers (i.e., State-Trait Anxiety Inventory, Stress Appraisal of Acute Stress) but also physiological indicators (i.e., HR, HRV, SCR) at various points throughout the conditions. This comprehensive data collection approach allowed for an evaluation of parasympathetic rebounds among individuals, providing a nuanced understanding of individual stress responses.

To explore the effects of emotion regulation strategies, the following research questions and hypotheses were proposed:

Research Question 1: How does cognitive reappraisal impact heart rate variability and skin conductance responses during acute social stress induced by the TSST as compared to expressive suppression?

a. Individuals employing cognitive reappraisal will have a higher HRV and a reduced SCR, indicating enhanced parasympathetic nervous system activation.
b. Those using expressive suppression will exhibit higher SCR and lower HRV, reflecting greater sympathetic nervous system activation.

Research Question 2: How does the use of cognitive reappraisal versus expressive suppression influence subjective stress ratings during various parts of the TSST?

a. Participants using cognitive reappraisal will report lower subjective stress than those employing expressive suppression, as they believe they have methods to deal with various stressors.

Research Question 3: How do cognitive reappraisal and expressive suppression affect heart rate recovery after stress exposure?

a. Those employing cognitive reappraisal are expected to have a faster heart rate recovery, reflecting efficient autonomic nervous system regulation.
b. Participants employing expressive suppression will have a delayed recovery due to sustained activation of the sympathetic nervous system.

Research Question 4: How do cognitive reappraisal and expressive suppression affect parasympathetic nervous system rebound, as measured by HRV and SCR, after completing a stress-inducing task?

a. Cognitive reappraisal will promote a stronger parasympathetic rebound, as shown by faster increases in HRV and decreases in SCR in those who use this strategy.
b. Expressive suppression will result in a delayed rebound of the parasympathetic system, reflecting prolonged stress.

Method

This research was a two-part study. Study 1 employed a cross-sectional survey design and was used to screen participants for Study 2, which involved an experimental design.

Participants

Participants were recruited through the Psychology and Business Participant Pools at the University of Regina. These pools included undergraduate students enrolled in a 100- or 200-level psychology course or an eligible business class. As compensation for their time, students received one credit upon completing Study 1 and two additional credits upon completing Study 2.

Study 1

Study 1 had over 800 participants who completed numerous psychological measures and an eligibility questionnaire. Eligibility for Study 1 required participants to be at least 18 years old and reside in Canada. Following the completion of the psychological measures, participants were invited to participate in Study 2. Those participants interested in Study 2 completed an eligibility questionnaire (Appendix A) to assess suitability. The primary purpose of Study 1 was to determine individuals' use of each emotion regulation strategy and to screen individuals to find participants who were eligible for Study 2.

Study 2

An a priori power analysis using G*Power was conducted to determine the required sample size for a linear multiple regression (Faul et al., 2009). Results indicated that a minimum sample of 68 participants would be necessary to detect medium-sized effects, assuming a statistical power level of 0.80 and an alpha (α) value of .05. While Study 2 fell short of this target with 58 participants, it remains adequately powered for planned analyses. All participants provided psychological and electrodermal activity (EDA) data, but due to malfunctions with the equipment, electrocardiogram (ECG) data was collected from only 38 participants, possibly limiting the statistical power of HR and HRV analyses.

Eligibility Criteria for Study 2. Study 2 had specific eligibility criteria to control for various factors influencing stress responses. This screening process ensured that participants included in Study 2 were at relatively low risk of experiencing adverse effects.

Participants assigned female at birth were required to have regular menstrual cycles and not be using any hormonal contraceptives. Female participants who did not menstruate, were currently pregnant or breastfeeding, or had irregular menstrual cycles were excluded. This criteria was necessary to regulate hormone levels across female participants, as fluctuations in estrogen and progesterone throughout the menstrual cycle influence stress reactivity (Kudielka & Kirschbaum, 2005). Additionally, participants' use of alcohol, nicotine, cannabis, or illicit drugs over the last month was evaluated. Indication of potential substance abuse resulted in exclusion, as that is known to influence stress response (Childs & de Wit, 2009).

The questionnaire also assessed participants' mental and medical health history. Individuals diagnosed with or currently receiving treatment for distressing mental health disorders such as social anxiety disorder, post-traumatic stress disorder, schizophrenia, mania, or psychosis were excluded from the study. Participants with diagnosed phobias related to public speaking or math were ineligible. In terms of medical health, participants with a history of cardiovascular diseases, recent heart attacks, or on medication affecting HR or blood pressure were excluded. Similarly, participants diagnosed with endocrine disorders, neurological or neuromuscular diseases affecting movement, or on medications such as antidepressants, benzodiazepines, stimulants, or antipsychotics were not eligible to participate. All of these disorders and medications have been demonstrated to influence stress responses (Kudielka et al., 2007).

All of these screening criteria were implemented to reduce variability in stress responses and allow for reliable comparisons across participants. This screening process ensured that participants included in Study 2 were likely to be relatively healthy, both mentally and physically. It would also reduce the likelihood of participants experiencing adverse effects from participation in Study 2. The screening helped prevent the inclusion of individuals with conditions or medications that could interfere with the study's physiological and psychological assessments.

The detailed eligibility questionnaire can be found in Appendix A.

Materials

Study 1 was conducted remotely via Qualtrics and required participants to use their own electronic devices with internet access.

As Study 2 involved the collection of physiological data during an in-person experiment, the BIOPAC MP160 Starter System with AcqKnowledge (version 5.0.8) data acquisition software was used to measure HR, HRV, and EDA. To measure HR and HRV, the study employed an ECG100D Smart Amplifier, BN-EL45-LEAD3 lead, and three single-use pre-gelled electrodes per participant. EDA was recorded with the EDA100D Smart Amplifier, BN-EDA-LEAD2 lead, and two disposable electrodes coated with isotonic gel per participant.

During the in-person experiment, participants completed psychological questionnaires via Qualtrics on a tablet provided to them. To establish baseline physiological levels, participants engaged in a neutral task where they were instructed to read *National Geographic Kids Why?: Over 1,111 Answers To Everything*. The experimental setup also included some key features to enhance the stress-inducing nature of the study. Panel members were provided with lab coats, pens, and paper. A small cardboard wall was used to conceal their materials. Additionally, panel members were provided with an arithmetic reference table with pre-calculated answers for the arithmetic task, along with coloured squares for implementing the stop protocol (Appendix B) if necessary.

Psychological Measures

Demographics Questionnaire (Appendix C)

The demographics questionnaire asked participants to self-report on factors known to shape social experiences and influence stress responses. This questionnaire provides four main variables: age, sex, gender, and racial background. Participants provided their age, sex, and gender through text-box responses, while racial background was collected through multiple-choice options, allowing participants to select multiple categories when applicable.

Emotion Regulation Questionnaire (ERQ; Appendix D)

Developed by Gross and John (2003), the ERQ is a 10-item measure designed to assess individual differences in the regulation of emotions. The ERQ focuses on two emotion regulation strategies: cognitive reappraisal and expressive suppression. Of the ten items in this scale, six of them assess CR, while the remaining four explore ES. Participants indicated how strongly they believe each item relates to them by rating it on a 7-point Likert scale, ranging from "strongly disagree" to "strongly agree." Scores range from 6 to 42 for CR and 4 to 28 for ES, with a higher score indicating greater use of that respective strategy. The ERQ has been demonstrated to be a reliable tool to measure emotion regulation as it has a high level of internal consistency on both CR (α = .89-.90) and ES (α = .76-.80; Preece et al., 2020).

State-Trait Anxiety Inventory-State (STAI-S; Appendix E)

The STAI-S subscale developed by Spielberger et al. (1970) is a 20-item scale used to assess temporary feelings of anxiety. Participants responded to statements using a 4-point Likert scale, ranging from "not at all" to "very much so." Scores are summed to yield a total score ranging from 20 all the way up to 80, with higher scores reflecting greater levels of state anxiety.

This scale is widely used in both research and clinical settings due to having been demonstrated to have good reliability and validity (α = .797; Barnes et al., 2002; Vitasari et al., 2011).

Stress Appraisal of Acute Stress (SAAS; Appendix F)

The four-item SAAS scale is a brief psychological measure designed to evaluate individual perceptions and interpretations of stressful situations (Lazarus & Folkman, 1984). This scale measures participants' cognitive appraisals of stress, which are known to influence psychological responses to acute stressors. The SAAS includes both a pre-task and post-task measure, with each item rated on a 7-point Likert scale ranging from "strongly disagree" to "strongly agree." The pre-task assessment is administered after participants receive task instructions, allowing them to anticipate their stress levels. The post-task measurement is given immediately after task completion, assessing how stressful the individual found the experience. The total score was obtained using the Threat Ratio scoring method. The sum of the scores on the first two questions (i.e., threat appraisal) is divided by the sum of the scores of the last two questions (i.e., challenge appraisal), calculating a ratio between threat appraisal and challenge appraisal. A Threat Ratio greater than 1 indicates a perception of the stressor as more threatening than challenging, while a ratio less than 1 suggests that participants view the stressor as a challenge more than a threat. The SAAS has been demonstrated to be a reliable and valid measure of individuals' appraisals of stressors, with a test-retest reliability of .75 (Dhakal, 2016).

Physiological measures

In addition to psychological measures, assessing physiological responses provided objective data and valuable insights into how individuals react to stressors. The ANS, which plays a critical role in stress regulation, is known to activate when individuals are experiencing a stressor and trigger a cascade of physiological changes. Key indicators of stress—HR, HRV and

EDA (assessed via SCL) were measured using the BIOPAC MP160 Starter System. This equipment is widely used and validated for physiological data analysis, featuring multiple amplifiers and sensors to accurately capture physiological signals from participants during the stressful conditions (BIOPAC Systems, 2023; Mohaddes et al., 2021).

Heart Rate and Heart Rate variability

Cardiovascular responses, particularly HR and HRV, are core indicators of autonomic nervous system activity in response to stress. HR, measured in beats per minute (bpm), has been demonstrated to increase during stress due to SNS activation, preparing the body for a fight-or-flight response (Battipaglia & Lanza, 2014). HRV, which refers to the variation in time intervals between heartbeats, provides insight into the dynamic balance between the two branches of the ANS during stress (Grégoire et al., 2023; Khan et al., 2019). The SNS drives the fight-or-flight response during stress by increasing HR and reducing parasympathetic activity. The PNS promotes relaxation and recovery by slowing the HR and enhancing HRV. This interplay of the ANS ensures the body can effectively respond to stress while also facilitating recovery when the stressor is removed.

A key HRV measure, the root mean square of successive differences (RMSSD) between normal heartbeats, indicates parasympathetic activity and is associated with high-frequency HRV (Berntson et al., 2005). Lower RMSSD values can reflect increased stress and reduced PNS modulation, while higher levels suggest greater parasympathetic control and relaxation (da Silva et al., 2015; Järvelin-Pasanen et al., 2018). HR and HRV were assessed using the BIOPAC MP160 system equipped with the ECG100D amplifier. Electrodes were placed according to Lead II configuration, with one electrode on the right wrist and an electrode on each inner ankle.

These physiological measures provided a comprehensive evaluation of the cardiovascular stress response.

Electrodermal Activity

EDA was measured by skin conductance. This measures changes in the skin's electrical conductance, which increases with sweat gland activity. An increase in SCL is modulated by the SNS and associated with heightened stress responses (Christopoulos et al., 2019). EDA was recorded using the BIOPAC MP160 system equipped with EDA100D amplifiers. An electrode was placed on the pointer finger and another on the middle finger of the participant's non-dominant hand, positioned between the first and second joints, with isotonic conductive gel to ensure maximal sensitivity (Kushki et al., 2011). The non-dominant hand was chosen to minimize movement that could interfere with the measurements.

Study 1 Procedure

Study 1 employed a cross-sectional survey design. Prior to participation, all participants read an informed consent sheet (Appendix G). Following this, participants completed the demographics questionnaire and a series of validated measures (i.e., Adverse Childhood Experiences-International Questionnaire, ERQ, Social Network Index, UCLA Loneliness scale, etc.). For this research, only the scales under 2.2 Psychological Measures were analyzed (i.e., demographics, ERQ). After completion of psychological measures, participants were asked if they wanted to participate in a follow-up study. Those interested were led to an eligibility questionnaire, and if determined eligible, they were able to sign up for Study 2 via the Participant Pool. After completion of Study 1, participants were presented with a debriefing form and mental health resources (Appendix J).

Study 2 Procedure

Study 2 involved a within-subject experimental design. Upon signing up, the researchers manually assessed participants' eligibility. Once deemed eligible, participants were emailed a link to a Google Calendar appointment list to schedule participation. Additionally, they were provided with the Study 2 consent form to review prior to their session.

In this study, participants underwent the TSST, which is a validated protocol to induce acute social stress. Participants were instructed to deliver a speech for a mock-job interview and completed a difficult arithmetic task in front of evaluators. They also completed the C-TSST, a low-stress variation of the TSST, therefore providing a comparison of stress responses. For the current study, the protocols have been adapted from Labuschagne et al. (2019), Het et al. (2009), and Taylor et al. (2010). See Appendix I for a detailed breakdown of the protocol.

Random Assignment

Random assignment was employed to control for order effects and ensure individual differences were evenly distributed across groups. Participants assigned to Group A completed the TSST condition first, followed by the C-TSST condition. Those assigned to Group B completed the C-TSST condition first, followed by the TSST condition.

Participants were randomly assigned to one of the two groups by a computer-generated randomization table. As participants signed up, they were assigned a number based on the order of enrollment (e.g., the first participant received 1, the second received 2, and so on). Group assignment was then determined by where their assigned number was placed during the randomization process.

The study aimed to achieve a total of 68 participants, with an equal representation of males and females assigned to each condition. To achieve this, 34 participants were allocated to each group, and separate randomization procedures were conducted for male and female participants to ensure each group consisted of equal proportions. This stratified randomization helped control for potential sex differences in stress responses. However, as the final sample included more females than males, female participants beyond 34 were assigned groups based on the remaining male participant allocations. Prior to data collection, numbers 1 through 34 were randomly assigned to either Group A or Group B.

Participant Orientation and Setup

Upon arrival, participants were welcomed by the lead experimenter and provided with a printed copy of the consent form, which they had previously received via email (Appendix H). Key points of the study were reviewed with the participants to ensure their understanding, and they were provided the opportunity to ask questions before signing the consent form. After obtaining consent, participants were prepared for physiological monitoring. The experimenter set up the necessary equipment and began data recording to measure physiological responses throughout the entire length of the study.

Panel members

To standardize the social stress component of the TSST, the panel always consisted of one male and one female confederate. These confederates consisted of undergraduate students at the University of Regina who were in the third or fourth year of a degree in business or psychology. Panel members were instructed to remain neutral and non-reactive throughout the speech and arithmetic task to maintain consistency across participants.

To counterbalance potential effects, the active panel member—who was responsible for delivering task instructions—was assigned through an alternating method. For female participants, the first was assigned a male active panel member, the second a female active panel member, and so forth in alternating order. The same method was applied to male participants, with the first receiving a male active panel member and the second a female active panel member, continuing in this pattern. This assignment allowed for an even distribution of male and female active panel members across participants.

Deception was included to increase the stress response. Participants were told that panel members were trained in monitoring and evaluating nonverbal behaviour. However, panel members were not trained in any behavioural analysis and were university students volunteering for the study. Efforts were made to ensure that participants did not know the panel members prior to participating.

TSST Condition

The TSST condition employed the Trier Social Stress Test and served as the stressful condition.

Participants first engaged in a 10-minute acclimation period, during which they completed a neutral task—reading *National Geographic Kids Why?: Over 1,111 Answers To Everything*—to establish baseline physiological levels. This segment was followed by a baseline measurement period, during which participants completed self-report measures, including the STAI-S. Physiological data was timestamped at the start and completion of the psychological measures.

After completing these initial measures, participants were introduced to the speech task. They were informed that they would be preparing for a mock job interview for their dream job, where they needed to convince trained panel members that they were the best applicant for the position. Participants were given three minutes to prepare their speech mentally, after which they completed another round of psychological measures, which included the STAI-S and pre-task

SAAS. Physiological data was timestamped at the beginning and end of the three-minute anticipation period.

Participants then delivered a five-minute speech in front of the panel members, who were instructed to remain neutral and refrain from providing encouragement. If a participant paused, panel members waited 20 seconds before asking them to continue with standardized prompts. Panel members timestamped physiological data at the start and end of the speech period. Following the speech task, participants completed a difficult arithmetic task, in which they sequentially subtracted 13 from 1022 aloud for five minutes. If they made an error, they were instructed to restart from 1022. Panel members again timestamped physiological data at the start and end of the arithmetic task.

After completing both tasks, participants filled out additional self-report measures, including the STAI-S and post-task SAAS. This condition concluded with an 8-minute recovery period followed by a final round of psychological measures. Physiological data was timestamped for a last time during this condition before and after the recovery period.

The length of each task was decided based on previous protocols (Het et al., 2009; Labuschagne et al., 2019; Taylor et al., 2010). Slight adaptations were made (i.e., acclimation of 10 minutes instead of 15 and recovery of 8 minutes instead of 35) and deemed appropriate since the ANS response is regulated faster than the HPA, which is what previous studies were investigating (Ulrich-Lai & Herman, 2009).

C-TSST Condition

This condition served as the non-stressful control condition and was designed to mirror the TSST while minimizing stress-inducing factors.

Participants followed the same general structure as in the TSST, including an acclimation period, anticipation period, a speech task, an arithmetic task, and a recovery period. However, differences were implemented in order to reduce the stress response. Unlike the TSST, participants were instructed to prepare a speech on a topic of their choice, such as a book, movie, or recent vacation. They were explicitly informed that their speech would not be judged, and no panel members were present during the task. They were again given three minutes to prepare mentally. Participants delivered their speech alone in the room and were asked to talk out loud and for the full time until the experimenter returned to the room.

Similarly, the arithmetic task for the C-TSST condition was considerably easier. Participants were asked to sequentially count up in intervals of 3, starting from 0. They were again asked to do so aloud and for the full time until the experimenter re-entered. As no one was judging their performance, errors did not require them to restart, ensuring the task was low-stress. Throughout this condition, physiological data was timestamped at the same critical points as in the TSST condition, ensuring a comparable dataset between conditions.

Debriefing

Following the completion of both conditions, participants were fully debriefed regarding the true nature of the study (Appendix K). They were informed that the TSST condition was explicitly designed to induce stress and that the panel members were not trained in evaluating non-verbal behaviour. Participants were reassured that their performance was not assessed or compared to others and does not reflect their abilities in any way. They were asked not to share details of the study with potential future participants to maintain the integrity of the research. Finally, participants were provided with a mental health resource pamphlet (Appendix L) in case of lingering distress and given the opportunity to ask questions before concluding.

Data Analyses

All analyses were conducted using IBM Statistical Package for the Social Sciences (SPSS; Version 28.0). Preliminary data screening was first performed to assess data entry accuracy, missing values, outliers, and normality assumptions. Once these issues were addressed and some variables were transformed, descriptive statistics were computed for demographic variables. Means and standard deviations were found for continuous variables (e.g., age), and frequencies and percentages were found for categorical variables (e.g., sex, gender, racial background). Paired samples t-tests were conducted to compare physiological responses between the TSST and C-TSST during the active stress phase to serve as a manipulation check. The 'Active' phase was operationalized as a composite average of the paradigms' anticipation, speech, and math components, representing the overall active stress period.

For primary analyses, multiple linear regressions and linear mixed-effects analyses were run. To test hypotheses I and II (i.e., whether CR and ES are significant predictors of physiological and subjective stress responses during the active stress phase), a total of seven multiple linear regressions were performed. Hypotheses III and IV (i.e., the effect that CR and ES have on HR recovery and parasympathetic rebound) were tested using three linear mixed-effects models. The use of this analysis accounted for repeated measurements across three time points (i.e., baseline, active, and recovery). For all three models, time, CR scores, ES scores, and their interactions with time were included as fixed effects.

Analyses were conducted on both non-transformed and transformed datasets. Results between the two models did not vary significantly for hypotheses I, II, or III; therefore, analyses on non-transformed values were reported. However, for hypothesis IV, the two datasets did vary in significant results. To ensure the robustness and validity of the findings, the results from the transformed models, which adhered to normality assumptions, were reported.

For all analyses, an alpha level of .05 was used to determine statistical significance.

Results

Preliminary Analysis

Data Cleaning

Exporting Data. Physiological data collected through the BIOPAC MP160 was stored using AcqKnowledge software. Due to noisy ECG data, it was decided to export only 30-second increments from each period of the TSST (i.e., baseline TSST, anticipation TSST, speech TSST, arithmetic TSST, recovery TSST) and matching periods from the C-TSST. Intervals were chosen based on when the most stressful period was expected to be during each section. For a detailed breakdown, see Appendix M. Data was exported as mean values for each period. The psychological measures for both Study 1 and Study 2 were exported through Qualtrics. A master Excel sheet was created to store physiological and psychological data, which was then exported into SPSS.

Accuracy of Data Entry. To ensure the integrity of the dataset, all dependent variables were screened through the examination of descriptive statistics. Means and standard deviations for all variables were within range.

Missing Data. Missing values for all dependent variables were screened using descriptive statistics. These values were addressed through mean imputation, whereby the mean of the available data was calculated and used as a replacement for missing entries (Acock, 2005; Donders et al., 2006). As there was only one missing value per variable, mean imputation was deemed an appropriate method to preserve overall distribution and maintain sample size (Acock, 2005).

Univariate Outliers. Univariate outliers were examined for all outcome variables. They were identified through the calculation of standardized z-scores for each variable, whereby a score exceeding an absolute value of 3.29 was classified as an outlier (Tabachnick & Fidell, 2019). Once identified, each outlier was replaced with a value that was one unit greater than the most extreme non-outlier value within the dataset, as recommended by Tabachnick and Fidell (2019). However, for one variable, this replacement approach did not work; in this case, the outlier was substituted with the most extreme non-outlier score in the dataset (Tabachnick & Fidell, 2019). These strategies were successful and allowed for the retention of data points while reducing the influence of deviant scores. Following the replacement approaches, z-scores were recalculated for all variables, and no values exceeded 3.29.

Assessment of Normality. Following the identification and treatment of univariate outliers, assumptions of normality were tested for all dependent variables. Normality for each variable was evaluated using the Shapiro-Wilk test, which is recommended for small sample sizes. Visual investigations of histograms and normality plots were conducted to have a comprehensive assessment of each variable's distribution. See Figure 1 for the original histograms and Q-Q plots. Initial assessments of several variables demonstrated deviations from normality. To address these, appropriate data transformations were applied, including log and square root transformations. The final values of the Shapiro-Wilk test are presented in Table 1, and Figure 2 shows the histograms and Q-Q plots for the transformed variables. While transformations to SAAS Post-task TSST were not able to make the distribution normal, the log transformation brought it closer to normality. Another variable, RMSSD Recovery TSST, was

Table 1

Assessment of Normality of Study Variables Using the Shapiro-Wilk Test

Variable	Transformation Applied	Shapiro-Wilk			Normality Assessment
		Statistic	df	p	
SCL Baseline TSST	Square Root	.984	58	.645	Acceptable
SCL Active TSST	Logarithmic	.974	58	.241	Acceptable
SCL Recovery TSST	Logarithmic	.987	58	.793	Acceptable
RMSSD Baseline TSST	Logarithmic	.969	38	.374	Acceptable
RMSSD Active TSST	None	.945	38	.063	Acceptable
RMSSD Recovery TSST	None	.943	38	.052	Borderline, acceptable upon visual inspection
HR Baseline TSST	None	.977	38	.603	Acceptable
HR Active TSST	None	.974	38	.506	Acceptable
HR Recovery TSST	None	.960	38	.186	Acceptable
STAI-S Anticipation TSST	None	.970	58	.163	Acceptable
STAI-S Post-task TSST	None	.976	58	.299	Acceptable

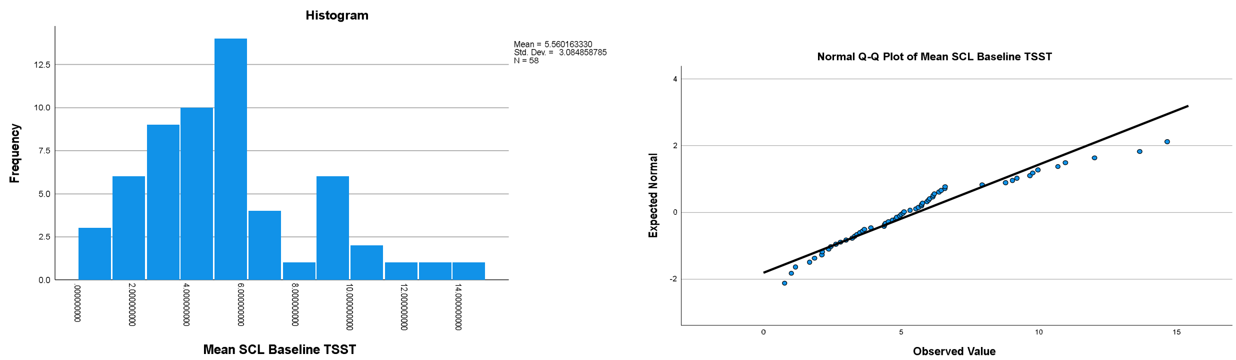
STAI-S Recovery TSST	None	.980	58	.458	Acceptable
SAAS Pre-task TSST	Logarithmic	.968	58	.127	Acceptable
SAAS Post-task TSST	Logarithmic	.954	58	.028	Marginal; improved post-transformation

Note. Visual inspection of histograms and normality plots supplemented statistical tests. Trier Social Stress Test (TSST); Skin Conductance Level (SCL); Root Mean Square of Successive Differences (RMSSD); Heart Rate (HR); State-Trait Anxiety Inventory-State subscale (STAI-S); Stress Appraisal of Acute Stress (SAAS).

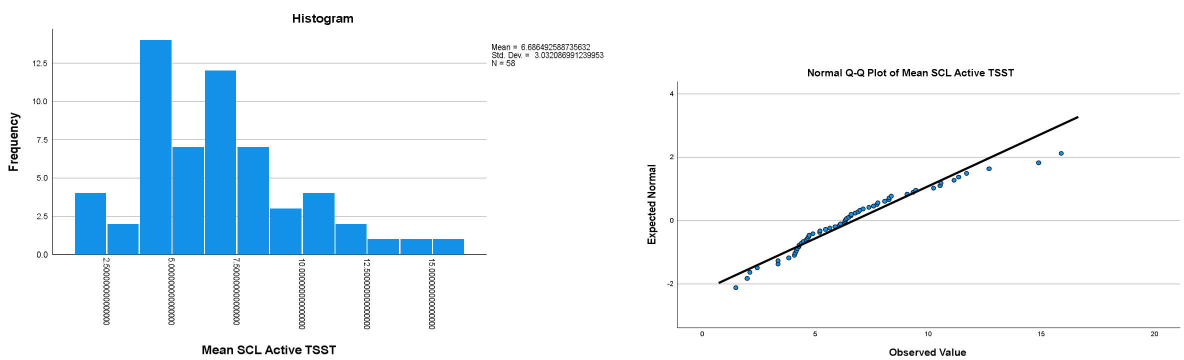
Figure 1

Original Histograms and Normal Q-Q Plots for Normality Assessments

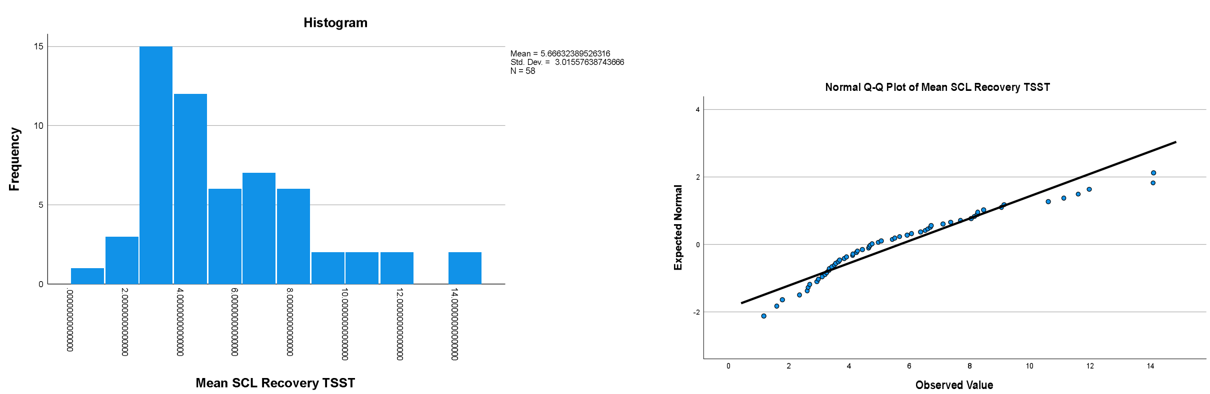
Mean SCL Baseline TSST



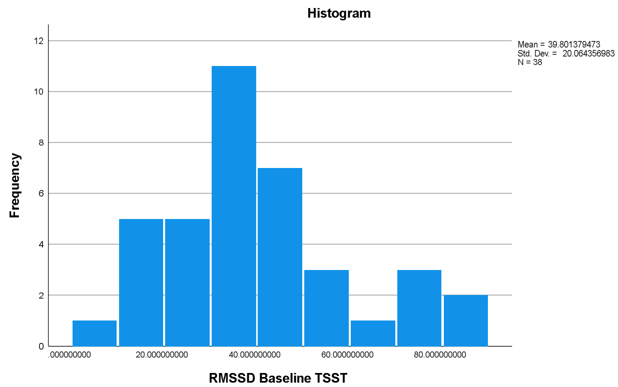
Mean SCL Active TSST

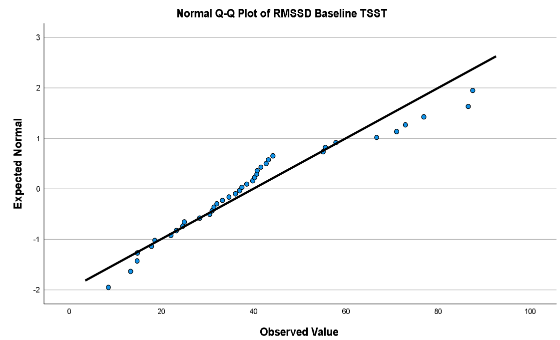


Mean SCL Recovery TSST

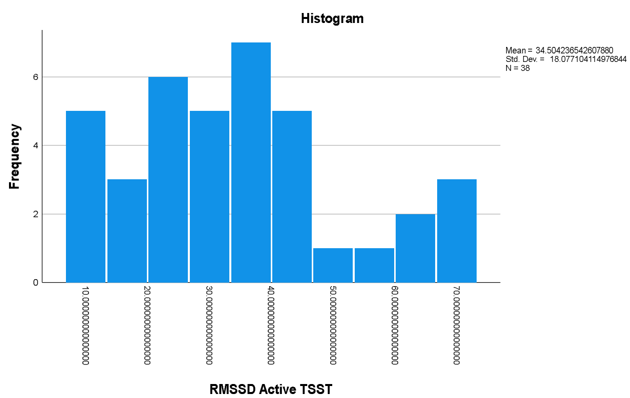


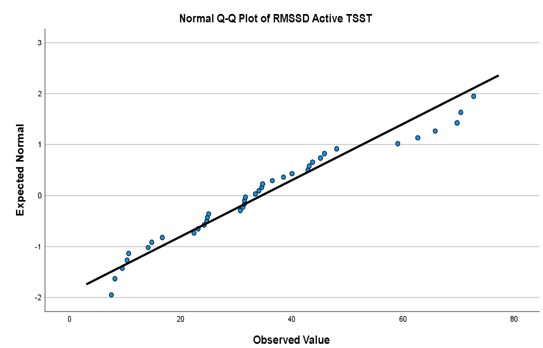
RMSSD Baseline TSST



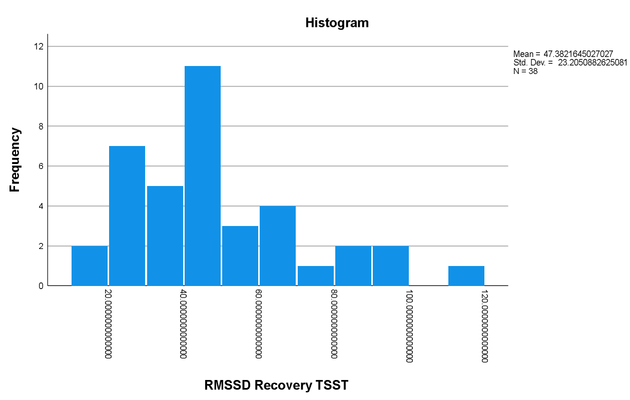


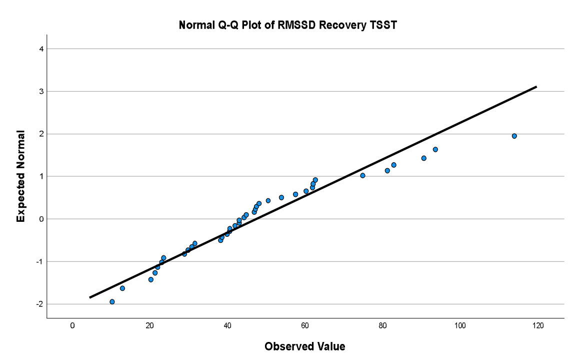
RMSSD Active TSST



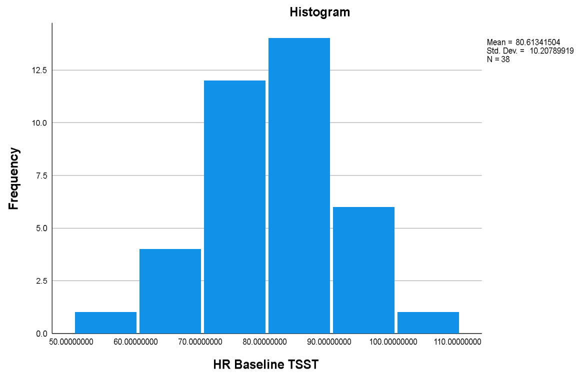


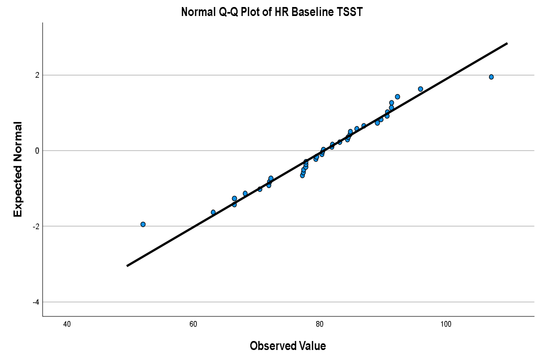
RMSSD Recovery TSST



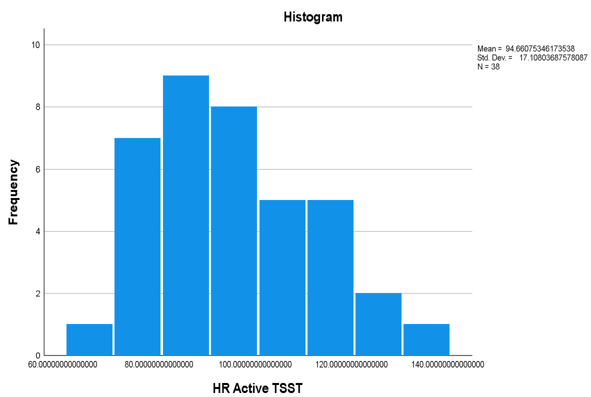


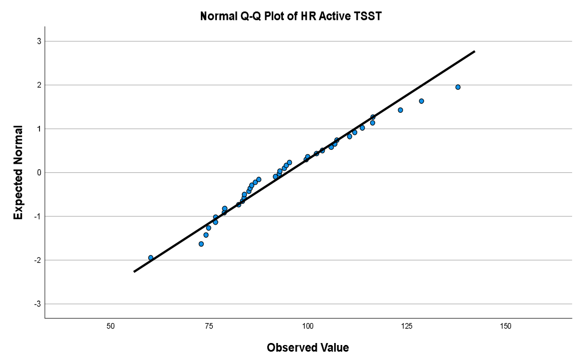
HR Baseline TSST



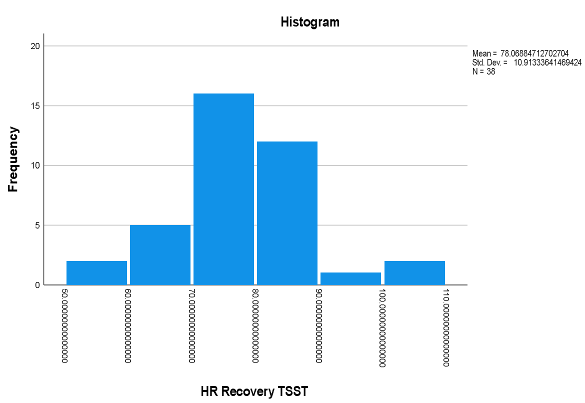


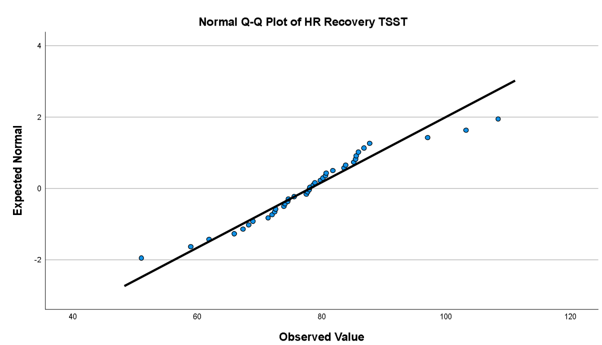
HR Active TSST



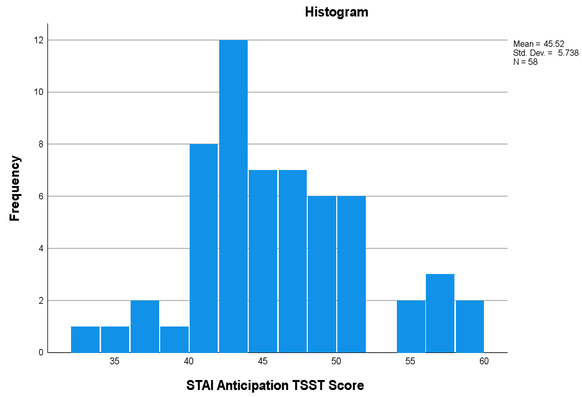


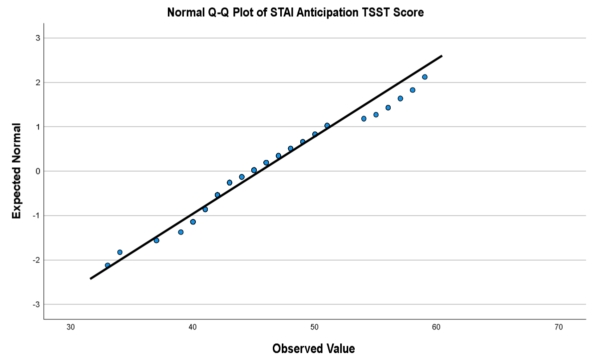
HR Recovery TSST



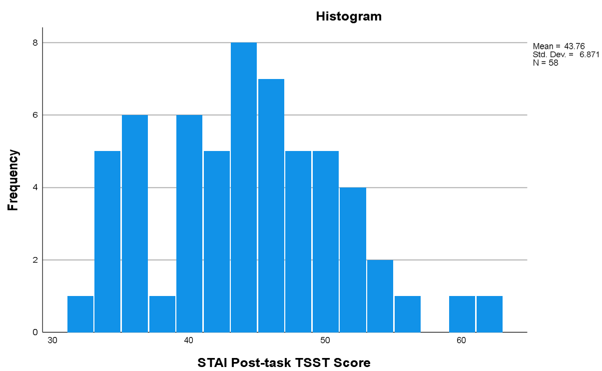


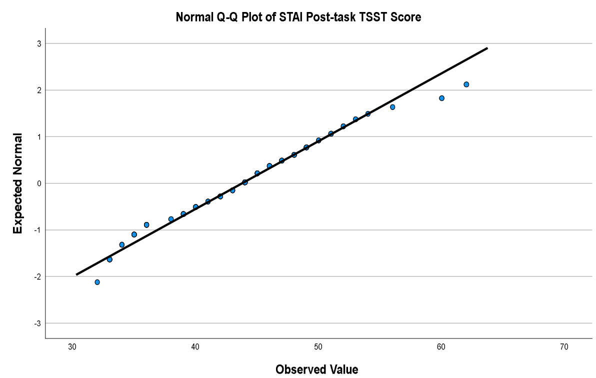
STAI Anticipation TSST Score



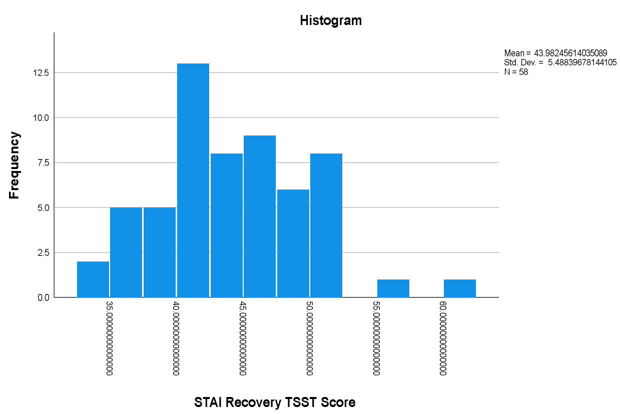


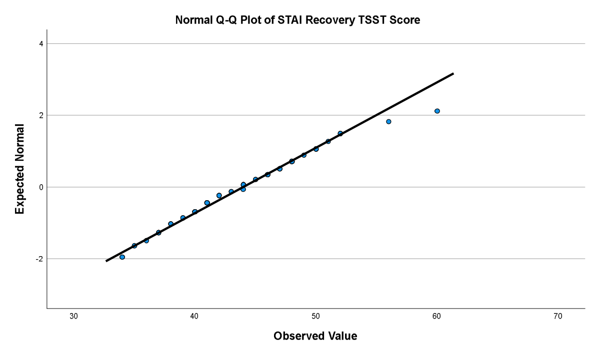
STAI Post-task TSST Score



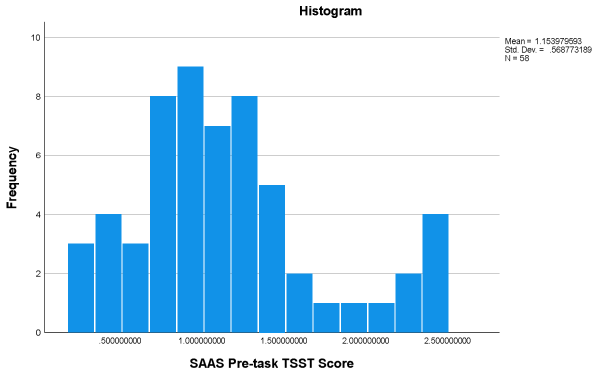


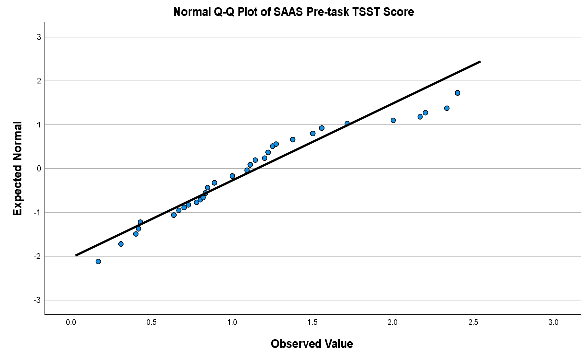
STAI Recovery TSST Score



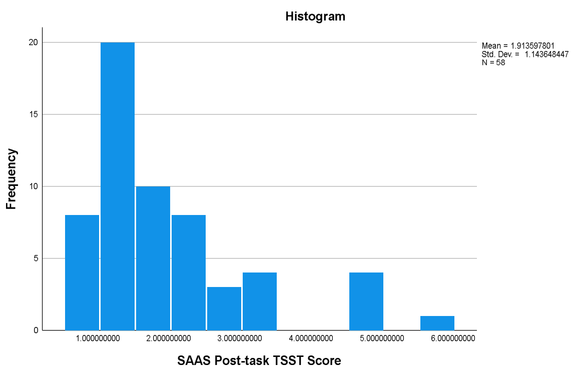


SAAS Pre-task TSST Score





SAAS Post-task TSST Score



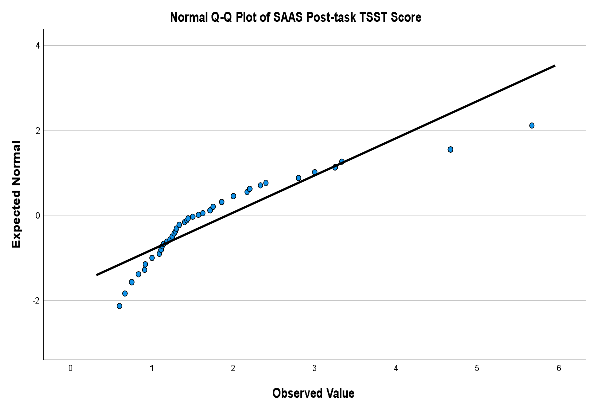
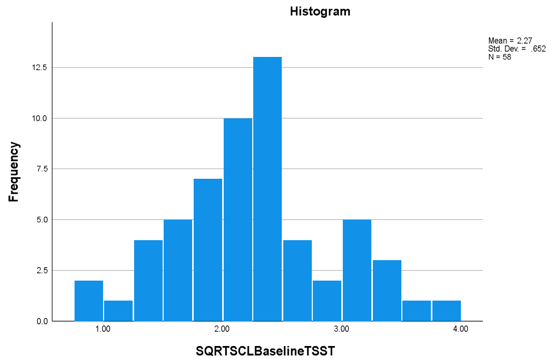
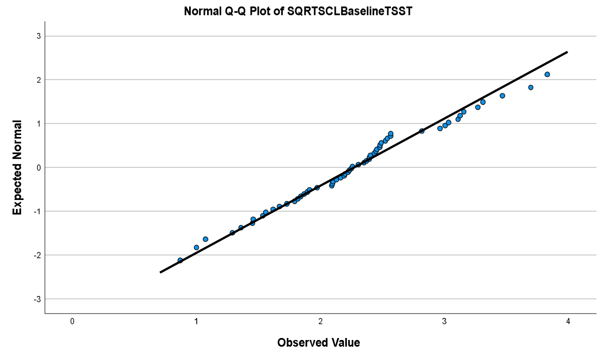


Figure 2

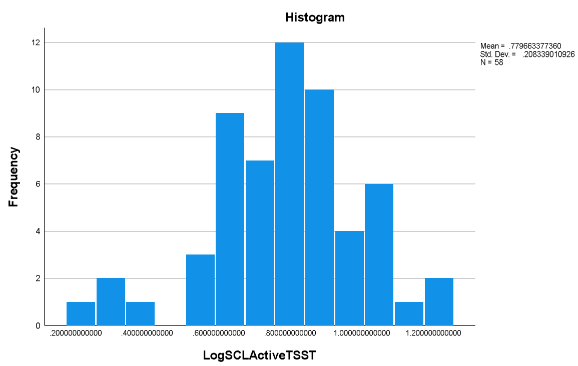
Transformed Histograms and Normal Q-Q Plots for Normality Assessment

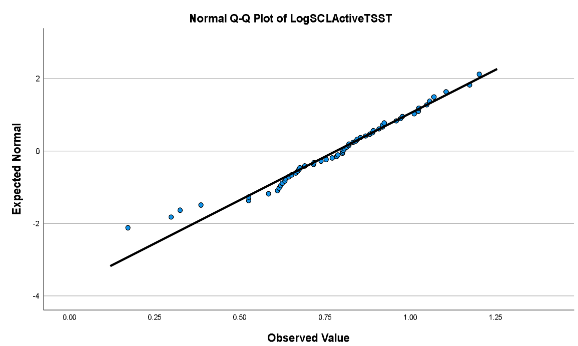
SQRT SCL Baseline TSST



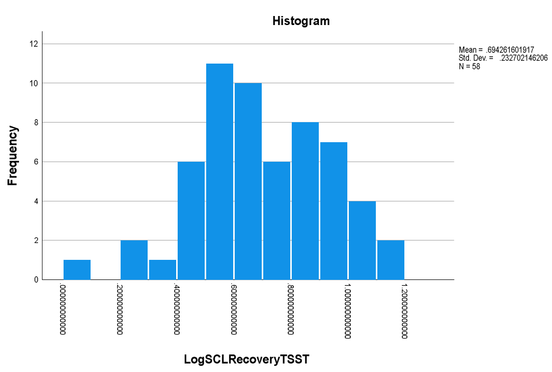


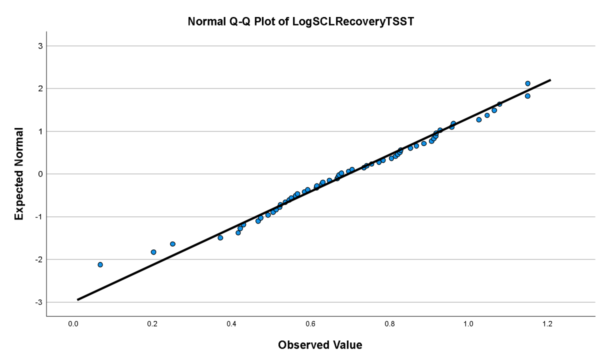
Log SCL Active TSST



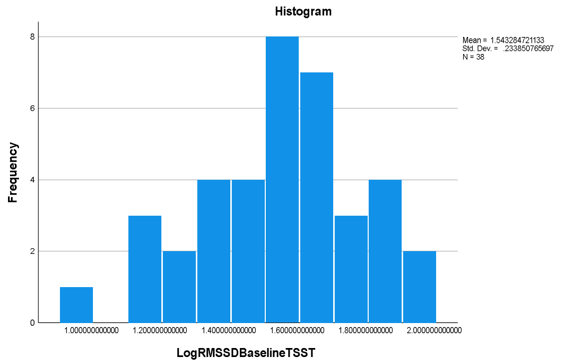


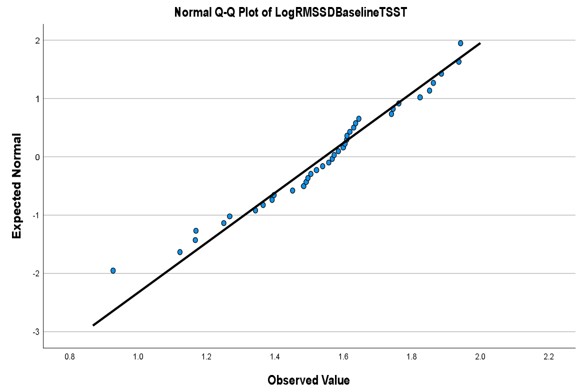
Log SCL Recovery TSST



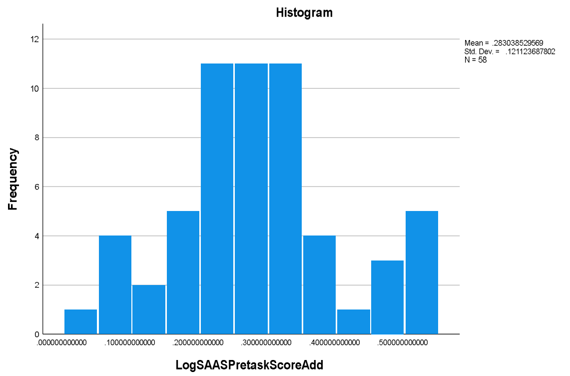


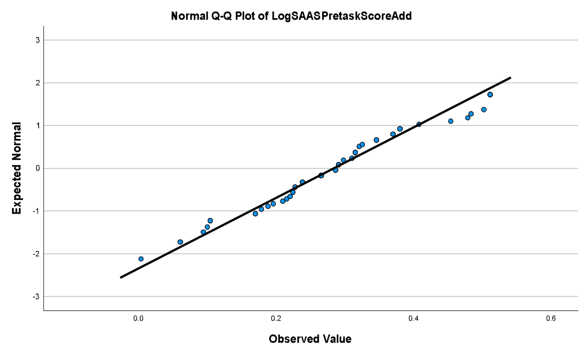
Log RMSSD Baseline TSST



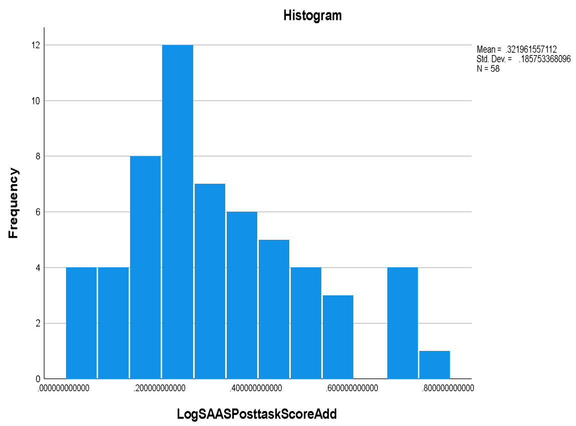


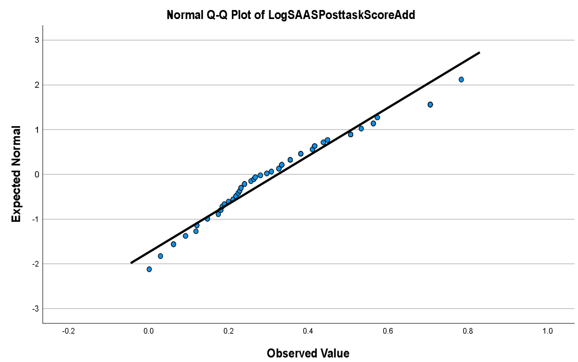
Log SAAS Pre-task Score





Log SAAS Post-task Score





borderline (p = .052), but visual inspection of the histogram and normality plot indicated minimal skewness, suggesting an acceptable distribution.

Subsequent analyses were conducted using both non-transformed and transformed variables to assess whether data transformation influenced the significance of the results.

Internal Consistency

As presented in Table 2, most scales and subscales demonstrated adequate reliability (i.e., α > .70) and were included in the analysis; these included both ERQ subscales of CR (α = .834) and ES (α = .791). In the TSST condition, the SAAS pre-task demand subscale (α = .890) and resource subscale (α = .731), as well as the post-task demand subscale (α = .765), were found to have adequate reliability. In the C-TSST condition, the STAI-S anticipation subscale (α = .730), STAI-S post-task subscale (α = .716), SAAS pre-task demand subscale (α = .781), SAAS pre-task resource subscale (α = .758), SAAS post-task demand subscale (α = .787), and SAAS post-task resource subscale (α = .778) also demonstrated adequate reliability. Some subscales had values that approached acceptability and were still included in the analysis; these include the STAI-S anticipation subscale (α = .529), STAI-S post-task subscale (α = .615), STAI-S recovery subscale (α = .565), and SAAS post-task resources subscale (α .628) for the TSST condition and the STAI-S recovery (α = .643) in the C-TSST condition.

Demographic Characteristics

The final sample for Study 2 consisted of 58 participants with a mean age of 21.33 years (SD = 5.09), ranging from 18 to 46 years old. For sex, 37.9% (n = 22) were male, and 62.1% (n = 36) were female. Regarding gender identity, the majority identified as female (58.9%, n = 33), followed by male (33.9%, n = 19), with smaller proportions for non-binary (3.6%, n = 2), and gender diverse (3.6%, n = 2); data were missing for 2 participants. In terms of racial background,

Table 2

Cronbach's Alpha for All Questionnaires

Variable	α	N of items
ERQ – Cognitive Reappraisal	.834	6
ERQ – Expressive Suppression	.791	4
TSST Condition		
STAI-S Anticipation	.529	20
STAI-S Post-task	.615	20
STAI-S Recovery	.565	20
SAAS Pre-task – Demand	.890	2
SAAS Pre-task – Resources	.731	2
SAAS Post-task – Demand	.765	2
SAAS Post-task – Resources	.628	2
C-TSST Condition		
STAI-S Anticipation	.730	20
STAI-S Post-task	.716	20
STAI-S Recovery	.643	20
SAAS Pre-task – Demand	.810	2
SAAS Pre-task – Resources	.758	2
SAAS Post-task – Demand	.787	2
SAAS Post-task – Resources	.778	2

Note. N = 58. Emotion Regulation Questionnaire (ERQ); Trier Social Stress Test (TSST); Control-TSST (C-TSST); State-Trait Anxiety Inventory-State subscale (STAI-S); Stress Appraisal of Acute Stress (SAAS).

the largest group was South Asian (38.6%, $n = 22$), followed by Black (25.9%, $n = 15$), then White (17.2%, n = 10), then Southeast Asian (6.9%, $n = 4$), and Middle Eastern (3.4%, $n = 2$). Additionally, one participant identified as Latino (1.7%, $n = 1$), one as Indigenous and White, one as East Asian and Southeast Asian, and one as North African. One case was missing for race. Demographic characteristics of participants are summarized in Table 3.

Manipulation Check

The manipulation check aimed to confirm whether the TSST successfully elicited greater physiological stress responses compared to the C-TSST. Paired samples t-tests were conducted for the three physiological measures collected during the active phase: SCR measured via SCL, HRV measured via RMSSD, and HR. One-tailed p-values are reported, given the direction of the hypothesis. These results remained significant in the two-tailed tests, further supporting the robustness of the TSST as an effective stress-inducing protocol. Table 4 summarizes the following results, and Figure 3 presents a visual.

Skin Conductance Level. There was a significant difference in SCL between the TSST and C-TSST, $t(57) = -2.27$, $p = .014$ (one-tailed), with higher SCL observed during the TSST ($M = 6.69$, $SD = 3.03$) compared to the C-TSST ($M = 6.21$, $SD = 3.43$). The effect size was small to moderate (Cohen's $d = -.297$, 95% CI [-.559, -.033]).

Heart Rate Variability. HRV was significantly lower in the TSST compared to the C-TSST, $t(37) = 2.66$, $p = .006$ (one-tailed), indicating greater parasympathetic withdrawal under stress. RMSSD values were lower in the TSST ($M = 34.5$, $SD = 18.08$) than in the C-TSST ($M = 41.7$, $SD = 17.36$). The effect size was moderate (Cohen's $d = .431$, 95% CI [.095, .761]).

Heart Rate. HR was significantly higher in the TSST compared to the C-TSST, $t(37) = -5.88$, $p < .001$ (one-tailed), with TSST eliciting a higher mean HR ($M = 94.66$, $SD = 17.11$)

Table 3

Participant Demographics

Variable	*M* (*SD*)	Range	Frequency (*n*)	Percentage (%)
Age (in years)	21.33 ± 5.09	18-46		
Sex				
Female			36	62.1%
Male			22	37.9%
Gender Identity				
Female			33	58.9%
Male			19	33.9%
Non-binary			2	3.6%
Gender Diverse			2	3.6%
Prefer not to answer			2	3.6%
Racial Background				
South Asian			22	38.6%
Black			15	25.9%
White			10	17.2%
Southeast Asian			4	6.9%
Middle Eastern			2	3.4%
Latino			1	1.7%
Indigenous & White			1	1.7%
East Asian & Southeast Asian			1	1.7%

North African	1	1.7%
Prefer not to answer	1	1.7%

Note. N = 58. M and *SD* are used to represent mean and standard deviation, respectively.

Table 4

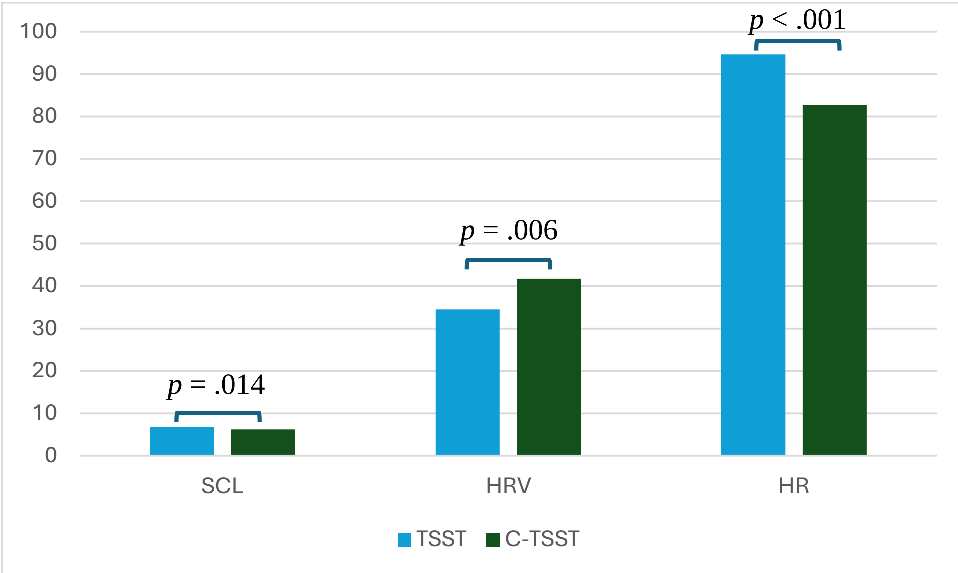
Manipulation Check: Physiological Responses During the TSST and C-TSST

Measure	TSST		C-TSST		*t*(df)	*p* (one-tailed)	Cohen's *d* [95% CI]
	M	*SD*	*M*	*SD*			
SCL	6.69	3.03	6.21	3.43	-2.27 (57)	.014	-.297 [-.559, -.033]
HRV	34.5	18.08	41.7	17.36	2.66 (37)	.006	.431 [.095, .761]
HR	94.66	17.11	82.64	9.59	-5.88 (37)	< .001	-.954 [-1.335, -.565]

Note. Trier Social Stress Test (TSST); Control-TSST (C-TSST); Skin Conductance Level (SCL), Heart Rate Variability (HRV), Heart Rate (HR). *M* and *SD* are used to represent mean and standard deviation, respectively.

Figure 3

Manipulation Check: Physiological Responses During the TSST and C-TSST



Note: Trier Social Stress Test (TSST); Control-TSST (C-TSST); Skin Conductance Level (SCL); Heart Rate Variability (HRV); Heart Rate (HR) compared to the C-TSST (*M* = 82.64, *SD* = 9.59). The effect size was large (Cohen's *d* = -.954, 95% CI [-1.335, -.565]).

Having confirmed the effectiveness of the stress manipulation, analyses proceeded to test the primary hypotheses regarding the impact of emotion regulation strategies on physiological and subjective stress responses.

Primary Analyses

Hypothesis I: Emotion Regulation and Physiological Reactivity

Two multiple linear regression analyses with CR and ES as predictors were conducted to test hypothesis I. The dependent variables were HRV and SCR during the active TSST phase.

Neither CR nor ES significantly predicted HRV or SCR during the active stress phase. For HRV, the regression model was non-significant, $F(2,35) = .117$, $p = .890$, $R^2 = .007$. Both CR scores ($\beta = -.063$, $p = .715$) and ES scores ($\beta = .040$, $p = .817$) were not significant predictors. Similarly, for SCR, the model was non-significant, $F(2,55) = .546$, $p = .582$, $R^2 = .019$, with CR ($\beta = -.139$, $p = .302$) and ES scores ($\beta = -.022$, $p = .872$) also being non-significant.

Hypothesis II: Emotion Regulation and Subjective Stress

Hypothesis II was tested through five multiple linear regressions. CR and ES served as predictors for all of these analyses. Dependent variables included scores on STAI-S and SAAS during the TSST condition.

For subjective stress measured by these scales, regression models were largely non-significant. The only exception was the SAAS Pre-task TSST, $F(2,55) = 4.587$, $p = .014$, with the model explaining for 14.3% of the variance ($R^2 = .143$). ES emerged as a significant predictor ($\beta = .301$, $p = .020$), indicating that higher ES scores predicted greater pre-task stress appraisals. CR did not significantly predict any subjective stress measures. Models for STAI-S Anticipation (p = .499), Post-task (p = .180), and Recovery (p = .263), as well as SAAS Post-task (p = .872), were all non-significant.

Table 5 presents a summary of all seven multiple regressions, while Table 6 reports on the correlation between variables.

Hypothesis III: Emotion Regulation and HR Recovery

A linear mixed-effects model was conducted to test hypothesis III. The overall model demonstrated a marginal pseudo R^2 of .279, indicating that approximately 27.9% of the variance in HR was explained only by the fixed effects. The marginal R^2 reflects the variance accounted for by the fixed effects only, excluding any contributions from random effects. The main effect of time was not significant, $F(2,105) = 1.751$, $p = .179$ and neither CR scores ($F(1,105) = .023$, $p = .880$) nor ES scores ($F(1,105) = 3.512$, $p = .064$) significantly predicted HR across time points. Moreover, there were no significant interactions between time and CR scores, $F(2,105) = .013$, $p = .988$, or between time and ES scores, $F(2,105) = .899$, $p = .410$.

Hypothesis IV: Emotion Regulation and Parasympathetic Rebound

Hypothesis IV was also tested through linear mixed-effects models with separate models estimated for HRV and SCR.

The HRV model had a marginal pseudo R^2 of .589, indicating that approximately 58.9% of the variance in HRV was explained by the fixed effects. However, despite the high pseudo R^2, the lack of significant fixed effects suggests that the predictors did not meaningfully contribute to explaining changes in HRV. Specifically, time ($F(2,105) = 1.573$, $p = .212$), CR scores ($F(1,105) = .874$, $p = .352$), ES scores ($F(1,105) = .003$, $p = .956$), interactions between time and CR

Table 5

Multiple Linear Regression Results with CR and ES as Predictors of Physiological and Subjective Stress Markers.

Variable	Predictor	B	95% CI	β	*t*	*p*
HRV Active	CR	-.140	[-.914, .633]	-.063	-.369	.715
	ES	.123	[-.945, 1.190]	.040	.233	.817
SCL Active	CR	-.054	[-.158, .050]	-.139	-1.041	.302
	ES	-.012	[-.156, .132]	-.022	-.162	.872
STAI-S Anticipation	CR	-.050	[-.246, .146]	-.068	-.510	.612
	ES	.140	[-.132, .412]	.138	1.031	.307
STAI-S Post-task	CR	.199	[-.032, .429]	.226	1.728	.090*
	ES	.138	[-.182, .458]	.113	.866	.390
STAI-S Recovery	CR	.136	[-.049, .321]	.194	1.471	.147
	ES	.111	[-.146, .368]	.114	.864	.391
SAAS Pre-task	CR	-.015	[-.033, .003]	-.208	-1.665	.102
	ES	.030	[.005, .056]	.301	2.402	.020**
SAAS Post-task	CR	.004	[-.035, .044]	.030	.222	.825
	ES	.013	[-.041, .068]	.066	.490	.626

Note. Heart Rate Variability (HRV); Skin Conductance Level (SCL); State-Trait Anxiety Inventory-State subscale (STAI-S); Stress Appraisal of Acute Stress (SAAS); Cognitive Reappraisal (CR); Expressive Suppression (ES). * indicates $p = .09$; ** indicates $p < .05$.

Table 6

Correlation Matrix of Key Variables

Variables	1	2	3	4	5	6	7	8	9
1. CR Score	1.000								
2. ES Score	-.073	1.000							
3. RMSSD	-.071	.053	1.000						
4. SCL	-.138	-.012	—	1.000					
5. SAAS Pre-task	-.230**	.316**	—	—	1.000				
6. SAAS Post-task	.025	.064	—	—	—	1.000			
7. STAI-S Antic	-.078	.143	—	—	—	—	1.000		
8. STAI-S Post	.218*	.097	—	—	—	—	—	1.000	
9. STAI-S Recovery	.186*	.100	—	—	—	—	—	—	1.000

Note. Cognitive Reappraisal (CR); Expressive Suppression (ES); Root Mean Square of Successive Differences (RMSSD); Skin Conductance Level (SCL); Stress Appraisal of Acute Stress (SAAS); State-Trait Anxiety Inventory-State subscale (STAI-S). RMSSD correlations are based on a subset (n = 38) of the data, while the remaining variables included all participants (N = 58). Therefore, the correlation between CR scores and ES scores based on the regression with RMSSD are not the same as presented here, with a value of -.201 instead of -.073. * indicates p < .09; ** indicates p < .05.

Table 7

Summary of Linear Mixed-Effects Models

DV	Fixed Effect	*F*(df)	*p*-value	Marginal R^2
	Time	$F(2,105) = 1.751$	.179	
HR	CR Score	$F(1,105) = 0.023$	.880	.279
	ES Score	$F(1,105) = 3.512$	.064*	
	Time	$F(2,105) = 1.573$	.212	
HRV	CR Score	$F(1,105) = 0.874$	.352	.589
	ES Score	$F(1,105) = 0.003$	.956	
	Time	$F(2,105) = 16.520$	<.001**	
SCL	CR Score	$F(1,105) = 1.345$	.248	.759
	ES Score	$F(1,105) = 1.254$	.264	

Note. Heart Rate (HR); Heart Rate Variability (HRV); Skin Conductance Level (SCL); Cognitive Reappraisal (CR); Expressive Suppression (ES). * indicates $p < .09$; ** indicates $p < .001$.

(F(2,105) = 1.649, p = .197), and between time and ES (F(2,105) = .093, p = .911) were all non-significant.

For SCR, the model accounted for a marginal pseudo R^2 of .759, with fixed effects explaining approximately 75.9% of the variance. While this suggests a substantial proportion of explained variance, only time was a significant predictor, F(2,165) = 16.520, p < .001. However, CR (F(1,165) = 1.345, p = .248), ES (F(1,165) = 1.254, p = .264), interactions between time and CR (F(2,165) = .505, p = .605), and between time and ES (F(2,165) = .498, p = .609) were not significant.

Table 7 reports a summary of the three linear mixed-effects models.

Discussion

Summary

This current study aimed to explore how two distinct emotion regulation strategies (i.e., cognitive reappraisal and expressive suppression) influence physiological and psychological stress responses. The TSST and C-TSST were employed to induce acute social stress. The study assessed whether CR and ES predicted HR, HRV, SCR, subjective stress appraisals, and physiological recovery following stress. Previous research has demonstrated that CR facilitates adaptive stress regulation while ES is associated with heightened stress responses (Butler et al., 2003; Moore et al., 2008; Wang & Saudino, 2011). Therefore, it was hypothesized that participants employing CR would demonstrate higher HRV, reduced SCR, reduced subjective stress ratings, and more efficient physiological recovery compared to those using ES.

Overall, the findings did not support the majority of these hypotheses. HRV and SCR levels during the active stress phase did not significantly vary across participants based on their use of emotion regulation strategies. CR and ES also did not meaningfully predict physiological recovery following exposure to the TSST. However, ES was found to be associated with elevated pre-task subjective stress appraisals. This relationship potentially indicates that individuals who typically rely on suppression may perceive upcoming stressors as more threatening. While the linear mixed-effects models revealed high marginal pseudo-R^2 values, suggesting substantial variance explained, only one of the fixed effects in one model reached statistical significance. These results suggest that while emotion regulation strategies may play a role in stress perception, their direct influence on physiological stress markers remains less clear.

Interpretation

Manipulation Check

A manipulation check was conducted to determine if the TSST did in fact induce more stress than the control version. This evaluation confirmed that the TSST effectively elicited greater physiological stress responses compared to the C-TSST, as observed by significant differences across all three physiological measures. Specifically, SCR was significantly higher during the TSST, indicating increased SNS activation. Although the effect size was small to moderate, this finding supports the effectiveness of the TSST in provoking physiological arousal. HRV was also found to be significantly lower during the TSST as compared to the C-TSST, reflecting greater parasympathetic withdrawal under stress. Additionally, HR was significantly higher during the TSST relative to the control, with a large effect size, further supporting the conclusion that the TSST is, in fact, stress-inducing.

Collectively, these findings validate the TSST as an effective acute social stressor in this study, producing substantial increases in physiological arousal relative to the low-stress C-TSST. This check confirms that the absence of significant associations between emotion regulation strategies and physiological responses in subsequent analysis is unlikely to be attributable to a failure in inducing stress. These results, therefore, reinforce the robustness of the TSST as a research tool for eliciting acute social stress and provide confidence in the validity of the paradigm employed.

Hypothesis I

It was hypothesized that participants who employ CR would demonstrate increased HRV and reduced SCR, which would indicate greater parasympathetic activation during the stress phase (Moore et al., 2008). In contrast, those employing ES were expected to exhibit lower HRV and heightened SCR, reflective of sympathetic activity (Butler et al., 2003). Contrary to expectations, HRV and SCR levels during the active stress phase did not differ significantly according to participants' use of either emotion regulation strategy. These findings suggest that, in the context of acute social stress, the reliance on CR or ES may not have a measurable impact on autonomic nervous system responses.

Hypothesis II

Hypothesis II posited that CR would be associated with lower subjective stress ratings, whereas ES would predict heightened subjective stress during the TSST. While no significant associations were observed for CR, ES was significantly associated with higher pre-task subjective stress appraisals as measured by the SAAS. Due to a positive regression coefficient, it can be concluded that individuals who typically rely on suppression have a higher threat ratio, indicating that they perceive upcoming stressors as more threatening. This idea means that they believe they lack the ability to deal with the stressor appropriately. This finding is consistent with prior research indicating that suppression is associated with heightened anticipatory anxiety (Braams et al., 2012; Helbig-Lang et al., 2015). This effect is possibly due to the cognitive overload required to inhibit emotional expression and the individual perception of reduced coping efficacy (Plass & Kalyuga, 2019; Rosenbaum et al., 2022). In other words, individuals may believe they lack the necessary resources to manage the upcoming stressor effectively.

However, it is notable that neither CR nor ES predicted subjective stress ratings following the stressor. One possibility is that once the stressor was concluded, participants felt immediate relief, and the decrease in demands may have overridden individual differences in emotion regulation strategy use (Kobylińska & Kusev, 2019; Segerstrom & Smith, 2019; Williams et al., 2009). These findings highlight the complex and dynamic nature of emotion regulation processes, particularly in situations as stressful as those induced by the TSST.

Hypothesis III

Hypothesis III proposed that CR would facilitate faster HR recovery following exposure to stress, whereas ES would be associated with delayed physiological recovery. Our findings did not support this hypothesis. Neither CR nor ES were found to significantly predict the trajectory of HR recovery. Interestingly, while the fixed effects were non-significant, the model accounted for a substantial proportion of variance (pseudo-R^2 = .279), suggesting that other unmeasured factors may have contributed to recovery patterns. This finding indicates that while emotion regulation strategies, as measured in this study, did not significantly explain differences in recovery, there remains a high amount of unexplained variance that requires further investigation. A possibility is that external variables, such as individual differences in baseline cardiovascular functioning, influenced by level of fitness and other individual factors, played a greater role in determining recovery trajectories than emotion regulation strategies (Bernstein & McNally, 2017; Forcier et al., 2006; Griffin & Howard, 2022).

Another consideration is the time frame used to measure recovery. HR recovery can take place over different time courses; therefore, it is possible that the post-stress period captured in this study was not sufficient to detect subtle differences linked to individual use of emotion regulation strategies. Some research suggests that longer recovery periods may be necessary to observe meaningful variability in autonomic recovery, especially when there are subtle individual differences (Labuschagne et al., 2019).

An interesting relationship that was observed was the association between ES and slower HR recovery following stress exposure. This relationship approached significance (p = .64) and should therefore be interpreted cautiously; the trend suggests that reliability on ES may be related to delayed physiological recovery. This finding would support previous literature as it would demonstrate that those who use suppression have stronger SNS activation and blunted parasympathetic rebound, leading to prolonged physiological arousal (Butler et al., 2003; Stange et al., 2017). Slower recovery of HR may reflect an impaired ability to downregulate following a stressor, contributing to additive stress burden over time (Geisler & Schröder-Abé, 2015). These results could highlight the potential harms of using ES as a coping strategy.

Hypothesis IV

Lastly, it was hypothesized that CR would promote a stronger parasympathetic rebound following the completion of the stressor, while ES would be associated with delayed recovery. Parasympathetic rebound was measured by changes in HRV and SCR. Faster increases in HRV and decreases in SCR were classified as a stronger rebound. The results did not support this hypothesis, as neither CR nor ES were significant predictors of HRV or SCR recovery patterns. However, similar to hypothesis III, the marginal pseudo-R^2 for both HRV (.589) and SCR (.759) were relatively high. This finding indicates that while the predictors of interest were not significant, substantial variance in recovery was accounted for by the model as a whole.

Interestingly, the fixed effect of time was significant in the SCR model, indicating the SCR decreased over the course of the TSST protocol, irrespective of individual differences in emotion regulation strategies. Based on the descriptive statistics, SCL seemed to be highest during the baseline period (*M* = 2.27, *SD* = .65), then during the active stress period (*M* = .78, *SD* = .21), followed by the recovery period (*M* = .69, *SD* = .23). These values would indicate that participants had greatest skin conductance during the baseline period and as they progressed through the stressful task, their SCR decreased.

Overall, these findings suggest that while time emerged as a significant factor in SCR recovery, neither CR nor ES significantly shaped parasympathetic rebound in this study. This unexpected outcome and the role of transformations highlight the need for careful interpretation and future research to clarify these dynamics.

Existing Literature

The findings from the present study partially align with existing literature on the role emotion regulation strategies play in individual stress responses, but also diverge significantly. Consistent with theoretical expectations, ES was associated with heightened stress appraisal, as measured by the SAAS, during the anticipation period (Caramanica et al., 2023; Dryman & Heimberg, 2018; Moore et al., 2008). This finding is consistent with prior research indicating that suppression is associated with heightened anticipatory anxiety, possibly due to the cognitive overload required to inhibit the expression of emotions (Helbig-Lang et al., 2015; Matthews & Campbell, 2009; Yip et al., 2008). Previous research demonstrates that habitual reliance on suppression can result in perceiving stressors as more threatening due to the belief that one lacks the necessary resources to effectively manage the upcoming stressor (Butler et al., 2003; Robazza et al., 2025; Schraub et al., 2011).

Importantly, these findings highlight the potential role of ES in shaping initial threat appraisals, which are critical in the stress response process (Yuan et al., 2024). According to Lazarus and Folkman's Transactional Model of Stress (1984), primary appraisals determine whether an event is perceived as stressful. Employment of an emotion-focused coping strategy may limit individuals' engagement in proactive strategies during the anticipation phase, leading to elevated perceptions of threat (Biggs et al., 2017; Herman & Tetrick, 2009). Prior research studies have demonstrated that suppression is linked to increased anxiety and greater physiological activation (Butler et al., 2003; Campbell-Sills et al., 2006). Results from this study support the role of ES in shaping subjective threat appraisals prior to stress exposure. However, no evidence in this current study was found to support the idea that ES results in greater physiological activation as well. Notably, there might be a possible trend between the employment of ES and slower HR recovery, reflecting slower activation of the PNS following stress exposure. Future research with larger sample sizes is needed to confirm this relationship.

Contrary to expectations and prior empirical findings, CR did not predict lower subjective stress ratings or improved physiological responses in this study (Perchtold-Stefan et al., 2020; Troy et al., 2010). Meta-analytic evidence has demonstrated that CR is associated with reduced physiological arousal, enhanced parasympathetic function, as well as lower self-reported stress ratings (Liu et al., 2019; Riepenhausen et al., 2022; Strover et al., 2024). The lack of significant association between emotion regulation strategies and physiological stress markers (i.e., HRV, SCR) contrasts with prior findings (de Veld et al., 2012; Krkovic et al., 2018). Previous literature has found that suppression is linked to increased sympathetic arousal and decreased HRV, while reappraisal tends to enhance parasympathetic activation (Brown et al., 2022; Cristea et al., 2014). The uniform physiological response observed across participants could potentially be explained by the intense nature of the TSST (Frisch et al., 2015; Helminen et al., 2021). Previous research on emotion regulation strategies in relation to general, everyday stress has found differences in stress responses and recovery. However, limited studies have looked at the influence of these strategies under acute social stress. Therefore, under intense situations of social evaluation, individual differences in emotion regulation may not be as pronounced (Blanke et al., 2022; Duijndam et al., 2020; Koval & Kuppens, 2012). They may only exert a minimal impact on autonomic stress markers, and other individual factors may play a larger role.

Another divergence from previous research was observed in the pattern of SCR. The significant fixed effect of time indicated that SCR decreased over the course of the TSST protocol, suggesting greater parasympathetic activity. This trajectory diverged from typical patterns reported in literature, which often show increased SCR during stress exposure followed by a gradual decline during recovery (Harrison et al., 2006; Lee et al., 2023; Mackersie & Calderon-Moultrie, 2016). One potential explanation for this discrepancy is the application of data transformations. Differences in patterns were observed when comparing the transformed means across time points to the original means. The original means followed the expected pattern, of greatest SCR value during the active stressor, and when mixed-effects models were done using these original values, no effect for time was found. However, as these values deviated from normal distributions, the transformed values were reported to adhere to assumptions of normality. Therefore, these results should be interpreted cautiously as significance was found only when the transformed variables were analyzed but not when the non-transformed variables were used. Both the active stress and recovery period had logarithmic transformations applied, and the baseline underwent a square root transformation. These variations in transformations, while necessary to meet assumptions of normality, may have influenced the pattern of results and contributed to the unexpected SCR trajectory. It could also be possible that participants in this study had unexpectedly high baseline SCR values. Elevated baseline SCR could be reflective of anticipatory stress prior to task onset, where participants feel nervous about what is to come (Argen et al., 2019; Dawson et al., 2011).

Alternatively, the non-significant findings could be reflective of limited statistical power. The small sample size, especially for HRV, may have limited the ability to detect subtle physiological differences related to emotion regulation strategies. Another possible explanation for all of these results is that the use of CR and ES is not mutually exclusive (Koval et al., 2015). Emotion regulation strategies are often flexible and employed in combination, depending on situational demands and individual differences (Aldao et al., 2015; Kobylińska & Kusev, 2019). Participants in the current study may have engaged in both strategies concurrently during the TSST, possibly obscuring the effects of each strategy. For example, a participant might initially attempt to reframe a stressor, but as pressure increases, they may resort to suppression as a secondary strategy. This mixed use of strategies may complicate the relationship between any single strategy and stress outcomes.

Overall, many findings from this study diverged from prior research. These discrepancies highlight the complex interplay between emotion regulation and individual stress responses. They emphasize the importance of considering a broader range of individual factors when examining physiological and subjective stress responses.

Implications

Several important implications emerge from the findings of the present study. First, the significant association between ES and threat appraisal highlights the role of suppression as a maladaptive regulation strategy. This relationship supports the idea that reliance on suppression shapes how individuals perceive stressors and their own ability to handle them. Believing that one lacks the resources to deal with this stressor can result in heightened anxiety, which is known to lead to negative health outcomes. Ultimately, this suggests that interventions aiming to reduce the reliance on suppression may be helpful in minimizing harmful stress responses.

Second, the possible trend between ES and slower HR recovery could indicate that ES is a maladaptive strategy. This delayed recovery may place additional strain on the cardiovascular system, leading to more adverse health outcomes later in life. If replicated in future studies, this relationship would highlight the importance of educating society about the harmful effects of ES and promote the use of more adaptive regulation strategies that facilitate faster recovery.

Third, the lack of significant findings for CR raises some important theoretical considerations. Although CR is regarded as an adaptive strategy, its benefits may not be universally applicable across all situational contexts. In situations involving intense stress, tendencies towards reappraisal may not be observed through physiological or subjective benefits. This finding underscores the importance of context in determining the effectiveness of strategies. Therefore, interventions aimed at promoting flexibility in strategy use may actually be more beneficial than advocating for only one approach.

Lastly, these findings contribute to the growing body of literature suggesting that the relationship between emotion regulation and stress responses is complex. This relationship could be influenced by a range of individual and situational factors, highlighting the importance of adopting a multifaceted approach when studying emotion regulation. It is important to integrate both subjective and physiological measures while still accounting for variables such as task intensity and baseline stress responses. Following such an approach could aid in the development of effective, individualized interventions that promote resilience in high-pressure environments.

Strengths

The present study contains several strengths that make it a valuable contribution to the literature of emotion regulation and stress. First, by including both subjective and objective measures of stress, it provides a comprehensive understanding of individual stress responses. The study captured multiple aspects of stress by integrating physiological stress markers (i.e., HR, HRV, SCR) along with self-reported measures (i.e., SAAS, STAI-S). Next, the experimental design, which included both the TSST and C-TSST, was a strength. As the two protocols were very similar in nature, it allowed for a strong manipulation check and confirmed that the TSST was successful in inducing stress. Third, the participant sample was relatively diverse, including people from various racial backgrounds and differing gender identities. This diverse sample can aid in the generalizability of the findings.

Limitations

However, there are several limitations that must be acknowledged. First, while the sample was diverse with respect to race and gender identity, participants were recruited through participant pools at the University of Regina. University samples are not the most representative, and findings can have poor validity due to this lack of representation (Andrade, 2021; McEwan, 2020). The generalizability of the findings remains limited to young adults within a specific age range, restricting conclusions about how emotion regulation strategies operate across the lifespan. Second, the sample size as a whole was smaller than intended and what was recommended for adequate statistical power. Physiological measures of HR and HRV, in particular, had quite a small sample size due to technical issues with the equipment. Therefore, the power of these results is limited, increasing the probability of type I and type II errors. Additionally, the unexpected findings in SCR trajectories and the reliance on transformed variables to meet normality assumptions complicate the interpretation of results. While transformations to these variables were necessary to meet assumptions and uphold scientific rigour, they may have influenced the patterns discovered and need to be considered when interpreting findings. Furthermore, the employment of self-report measures could lead to biases (e.g., social desirability) in participant responses. Also, ECG data was collected through lead-II placement, which involves having electrodes on the wrist and ankle. This placement is associated with a lot of noise due to frequent movement. Therefore, only 30-second intervals for each section of the protocol were involved in analysis, limiting the variability across the time periods. Lastly, due to equipment procurement delays, some participants had a couple of months' gap between the completion of Study 1 and participating in Study 2. It is possible that their emotion regulation strategies changed during this time, and their results on the ERQ were no longer applicable.

Future Directions

Future research that builds on the insights and limitations of the current study is needed to draw stronger conclusions. First, increasing sample sizes will be crucial to enhance statistical power. As the current study was underpowered, future investigations with larger and more representative samples will likely yield more trustworthy results regarding these relationships. This modification will increase the ability to detect subtle effects that emotion regulation strategies may have on individual stress responses. Also, extending research to include more diverse populations can help make the conclusions more generalizable. Understanding how emotion regulation strategies influence stress responses across the lifespan may offer valuable insights for intervention programs. Furthermore, to learn about the role that context plays in the effects of emotion regulation, future research can utilize different stress-inducing paradigms, including the Maastricht Acute Stress Test or the Cold Pressor Test (Smeets et al., 2012; Schwabe & Schächinger, 2018). By employing stressors of various intensities and durations, we can better understand the role of emotion regulation under different types of stress conditions. Additionally, the use of a different placement of electrodes should be considered when designing future studies. By having electrodes closer to the heart, there is less noise associated with the data, and stronger conclusions can be made (Gebhard et al., 2007; Tung, 2021). Lastly, examination of the role of emotion regulation flexibility may result in a more comprehensive understanding of stress regulation.

Implementing these adaptations to future studies offers promising ways of increasing our understanding of the complex relationship between emotion regulation and stress responses. Ultimately, this will be helpful in the creation of tailored intervention programs that promote individual well-being. Insights from these studies can inform clinical practices and public health initiatives that foster resilience.

Conclusion

The present study aimed to examine the influence of emotion regulation strategies on individual responses to acute social stress. Both physiological and psychological markers of stress were involved in this study, allowing it to contribute to the growing understanding of the impact of emotion regulation on stress responses. Through a manipulation check, results confirmed the effectiveness of the TSST in inducing stress, supporting the methodology applied in this study. The results also support current literature that finds ES as a predictor of heightened threat appraisal, providing insight into the role of maladaptive regulation strategies. Other findings in this study did not fully align with theoretical expectations, highlighting the complex relationship between emotion regulation and stress responses. Future research should look to incorporate diverse stress protocols and recruit larger and more diverse samples to draw stronger conclusions. The findings from this study, combined with further research, can aid in developing interventions that enhance stress resilience.

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Appendix A

Study 2 Eligibility Questionnaire

1. What sex were you assigned at birth? This means the sex that someone – typically a medical professional – gave you when you were born, which is often noted on your original birth certificate.
    a. Female (only participants who select this will see questions 2-8)
    b. Male
    c. Intersex
    d. Something else_______________

2. Do you use any form of hormonal contraceptives including, but not limited to, oral contraceptives (i.e., birth control pills), IUD, vaginal ring, skin patch, etc.?
    a. Yes (exclude)
    b. No

3. Do you menstruate (i.e. have a period)? If you are postmenopausal, please select "No."
    a. Yes
    b. No (exclude)

4. When was the first day of your last menstruation (i.e., period)? If you are currently menstruating, please select the day your current period started.
    a. Given a calendar option to select the date
    b. Information is needed to confirm participation when in the luteal phase

5. A "menstrual cycle" refers to the time between the start date of one period and the start date of the next period. Are your menstrual cycles relatively regular? In other words, can you predict the start date of your next period with relative accuracy?
    a. Yes
    b. Mostly
    c. No (exclude—need to accurately estimate luteal phase)

6. Approximately how long is your menstrual cycle? The average menstrual cycle length is approximately 26-30 days.
    a. Text box to enter number

7. Are you currently pregnant?
    a. Yes (exclude)
    b. No

8. Are you currently lactating and/or breast-feeding?
    a. Yes (exclude)
    b. No

9. Have you consumed alcohol, nicotine, cannabis, or illicit drugs in the past month?

a. Yes (only participants who select this will see questions 10-13)
b. No

Questions 10-13 are CAGE-AID scale to assess if there is potential substance abuse. If yes is selected twice or more, participants will be excluded.

10. Have you ever felt the need to cut down on your drinking, smoking, or other drug use?
    a. Yes
    b. No

11. Have people annoyed you by criticizing your drinking, smoking, or other drug use?
    a. Yes
    b. No

12. Have you ever felt guilty about drinking, smoking, or other drug use?
    a. Yes
    b. No

13. Have you ever felt you needed a drink or used drugs first thing in the morning to steady your nerves or to get rid of a hangover?
    a. Yes
    b. No

14. Have you ever been diagnosed with Social Anxiety Disorder by a physician or mental health care provider?
    a. Yes (exclude)
    b. No

15. Have you ever been diagnosed with Post-Traumatic Stress Disorder by a physician or mental health care provider?
    a. Yes (exclude)
    b. No

16. Have you ever been diagnosed with Schizophrenia by a physician or mental health care provider?
    a. Yes (exclude)
    b. No

17. Have you ever been told that you had experienced mania by a physician or mental health care provider?
    a. Yes (exclude)
    b. No

18. Have you ever been told that you had experienced psychosis by a physician or mental health care provider?
    a. Yes (exclude)
    b. No

19. Are you currently receiving treatment from a mental health professional for a diagnosed and currently distressing mental health disorder? If you have been previously diagnosed with a mental health disorder but are not currently actively experiencing symptoms, please select “No” for this question.
    a. Yes (exclude)
    b. No

20. Do you have any diagnosed phobias?
    a. Yes (only participants who select this will see question 21)
    b. No

21. What diagnosed phobia(s) do you have?
    a. **Manual exclusion necessary if participants indicate a diagnosed phobia of public speaking or math.**

22. In the past 6 months, have you taken any of the following types of prescription medications?

    Antidepressants: Examples include fluoxetine (Prozac), paroxetine (Paxil, Pexeva), sertraline (Zoloft), citalopram (Celexa) and escitalopram (Lexapro), duloxetine (Cymbalta, Drizalma Sprinkle), venlafaxine (Effexor XR), desvenlafaxine (Pristiq) and levomilnacipran (Fetzima), trazodone, mirtazapine (Remeron), vortioxetine (Trintellix), vilazodone (Viibryd) and bupropion (Forfivo XL, Wellbutrin), imipramine, nortriptyline (Pamelor), amitriptyline, doxepin and desipramine (Norpramin), tranylcypromine (Parnate), phenelzine (Nardil) and isocarboxazid (Marplan)

    Benzodiazepines: Examples include diazepam (Valium), alprazolam (Xanax), lorazepam (Ativan), clonazepam (Klonopin), midazolam (Versed)

    Stimulants: Examples include amphetamine/dextroamphetamine (Adderall), Ritalin and Concerta (methylphenidate), Dexedrine (dextroamphetamine), Vyvanse (lisdexamfetamine)

    Antipsychotics: Examples include risperidone (Risperdal), quetiapine (Seroquel), olanzapine (Zyprexa), ziprasidone (Zeldox), paliperidone (Invega), aripiprazole (Abilify) clozapine (Clozaril), chlorpromazine (once marketed as Largactil), flupenthixol (Fluanxol), afluphenazine (Modecate), haloperidol (Haldol), loxapine (Loxapac), perphenazine (Trilafon), pimozide (Orap), trifluoperazine (Stelazine), thiothixene (Navane) and zuclopenthixol (Clopixol)

    a. Yes (exclude)
    b. No

23. Have you ever been diagnosed with a cardiovascular disease? Examples include, but are not limited to, diseases such as coronary heart disease, heart failure, stroke, hypertensive heart disease, arrhythmia, and congenital heart disease.
    a. Yes (exclude)
    b. No

24. Have you had a heart attack in the past year?

a. Yes (exclude)
b. No

25. As far as you know, do any of the prescription medications you currently take have side effects involving changes to heart rate, blood pressure, or any other cardiovascular (i.e., heart, blood, etc.) entities?
    a. Yes (exclude)
    b. No

26. Have you ever been diagnosed with an endocrine disorder? Examples include, but are not limited to, diseases such as diabetes (type 1 or 2), hyperthyroidism, hypothyroidism, Graves' Disease, Cushing's Syndrome, and acromegaly.
    a. Yes (exclude)
    b. No

27. Have you ever been diagnosed with a neurological or neuromuscular disease that affects your ability to move? Examples include, but are not limited to, Bell's Palsy, Parkinson's Disease, Multiple Sclerosis (MS), Amyotrophic Lateral Sclerosis (ALS), and Muscular Dystrophy.
    a. Yes (exclude)
    b. No

If participants make it here, they are presented a code to sign up for Study 2 via the Participant Pool.

Appendix B

Stop Protocol

During the speech and math task portions of the TSST, panel members were responsible for monitoring the participant for signs of significant and dangerous distress. Panel members were to decide if the protocol should be terminated using the following method:

- Each panel member had three small pieces of paper; one was green (the default, indicating that there are no concerns for the participant), one was yellow (indicating concern for the participant's wellness), and one was red (suggesting that the panel member believes the protocol should be terminated)
- The green paper was automatically placed in the display spot. If panel members felt a significant level of concern for the participants' well-being, they would move the yellow piece of paper (initially off to the side) into the display spot. If they feel the protocol should be terminated, they should display the red piece of paper.
- For a consensus to be reached on terminating the protocol, both panel members must display the red piece of paper.
- Panel members were responsible for monitoring participants' behaviour and which paper the other panel member was displaying.
- If one panel member indicated concern and felt that the other panel member had not noticed, they could gently tap them and gesture to the paper.

Some signs that indicate an unacceptable level of distress include extremely rapid breathing, apparent difficulty breathing, apparent chest pain or pressure, appearance of light-headedness or dizziness, extreme shakiness, excessive sweating, sudden flushing of skin, crying, becoming obviously angry or aggressive, and being unable to speak and/or move.

If both panel members display a red piece of paper, the active panel member was instructed to interrupt the participant and say, "Thank you. You may stop". Once the participant has stopped, the active panel member should exit the room and alert the researcher.

Appendix C

Demographics Questionnaire

1. What is your current age? ______________________
    a. Prefer not to answer (only participants who select this instead of entering their age will be shown question 2)

2. Are you 18 years or older? **(needed for eligibility)**
    a. Yes
    b. No (not eligible)

3. What is your sex? ____________________
    a. Prefer not to answer

4. What is your gender? _____________________
    a. Prefer not to answer

5. We know that race is a social construct, and that race does not result in biological (including genetic) differences. However, our racial background still has important consequences for us, including how we are treated by individuals, groups, and Institutions.
   What is your racial background? Check all that apply:
    a. Black
    b. East Asian
    c. Southeast Asian
    d. Indigenous
    e. Latino
    f. South Asian
    g. White
    h. Another race category
    i. Not sure
    j. Prefer not to answer

Appendix D

Emotion Regulation Questionnaire

Options for all: Strongly disagree, Disagree, Slightly disagree, neutral, Slightly agree, Agree, Strongly agree, Prefer not to answer

1. ____When I want to feel more positive emotion (such as joy or amusement), I change what I'm thinking about.

2. ____ I keep my emotions to myself.

3. ____ When I want to feel less negative emotion (such as sadness or anger), I change what I'm thinking about.

4. ____When I am feeling positive emotions, I am careful not to express them.

5. ____When I'm faced with a stressful situation, I make myself think about it in a way that helps me stay calm.

6. ____ I control my emotions by not expressing them.

7. ____When I want to feel more positive emotion, I change the way I'm thinking about the situation.

8. ____ I control my emotions by changing the way I think about the situation I'm in.

9. ____When I am feeling negative emotions, I make sure not to express them.

10. ____When I want to feel less negative emotion, I change the way I'm thinking about the situation.

Appendix E

State-Trait Anxiety Inventory – State Subscale

Several statements which people have used to describe themselves are given below. Read each statement and select an answer to indicate how you feel right now, that is, at this moment. There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best. On a scale from 0 to 3, with 0 being not at all and 3 being very much so, how do you feel right now?

Options for all: 0 (not at all), 1 (a little), 2 (somewhat), 3 (very much so), prefer not to answer

1. I feel calm
2. I feel secure
3. I am tense
4. I feel strained
5. I feel at ease
6. I feel upset
7. I am presently worrying over possible misfortunes
8. I feel satisfied
9. I feel frightened
10. I feel comfortable
11. I feel self-confident
12. I feel nervous
13. I am jittery
14. I feel indecisive
15. I am relaxed
16. I feel content
17. I am worried
18. I feel confused
19. I feel steady
20. I feel pleasant

Appendix F

Stress Appraisal of Acute Stress

There will be a pre-task and a post-task SAAS measure. Options for both: Strongly disagree, Disagree, Somewhat disagree, Neutral, Somewhat agree, Agree, Strongly agree
Pre-task questions:

1. The upcoming task is very demanding.
2. The task will take a lot of effort to complete.
3. I feel that I have the abilities to perform the upcoming task successfully.
4. I'm the kind of person that does well on these types of tasks.

Post-task questions:

1. The task was very demanding.
2. I exerted a lot of effort during the task.
3. I felt that I had the abilities to perform well in the task.
4. I believe I performed well on the task.

Appendix G

Study 1 Participant Consent Form

Project Title: The Interplay Between Psychosocial Factors and the Acute Stress Response: Psychological and Physiological Considerations (Part 1; A Cross-sectional Survey)

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Purpose and Objectives of the Research:

- The aim of the current study is to investigate associations between adverse childhood experiences, adulthood social support, emotion regulation, perspectives on time, anxiety, and loneliness.
- Results will be used as part of Honours thesis projects and in journal articles and conference presentations. Results from this study will also be shared on the ARC Research Unit website (www.arcresearch.ca) and X (Twitter), Instagram, and Facebook (@ARCResearchUnit). Data obtained from this study may be used in future theses and/or publications.

Procedure:

- This online survey will ask you questions about yourself, including demographic information (age, gender, race, etc.), experiences during your childhood, your social network, your emotions, social factors, and perspectives on time.
- You must be 18 years or older and reside in Canada to participate in this online survey.
- You will also be given the opportunity to express interest in participating in a follow-up study and will be presented with a questionnaire to determine your eligibility.
- Completion of this survey is expected to take no longer than 60 minutes. Please note that this survey must be completed in one sitting or be reopened in the same browser to make sure no data is lost. From your last edit on the survey, you will have 1 week to complete it before the response is considered incomplete.
- This survey can be taken from any location with access to the internet.
- Please feel free to email any of the researchers to ask questions regarding the procedures and goals of the study or your role.

Funded by:

- The researchers each received financial support for their work on this project between May 2024 and August 2024 via an Undergraduate Student Research Award from the Natural Sciences and Engineering Research Council of Canada.

Potential Risks:

- Some questions in this survey address sensitive topics and may be distressing to participants. If you experience significant distress during or after completing this survey, we encourage you to call your local crisis helpline or emergency department. Additional resources include Regina Mobile Crisis Services (https://mobilecrisis.ca/), University of Regina Student Mental Health Centre (https://www.uregina.ca/student/counselling/), Mental Health Clinic located in Regina, SK, and the Suicide Crisis Helpline (https://988.ca/). At the end of the survey, these resources will be presented in more detail.
- You are encouraged to only answer those questions that you are comfortable answering. If you do not wish to answer one or more question(s), you can select “Prefer not to answer” or leave them blank (only applies to a few questions) to skip them.

Potential Benefits:

- Results from this study will contribute to the overall state of psychological knowledge by providing insight into several psychosocial factors and the interplay between them.

- Please note that no personal benefits from participation are guaranteed, aside from receiving course credit for participating.

Compensation:

- Participants registered through the Psychology Participant Pool: In exchange for your participation, you will receive one bonus mark towards your final grade in a psychology class that is registered in the Psychology Participant Pool.
- Participants registered through the Business Participant Pool: In exchange for your participation, you will receive one bonus mark towards your final grade in a Business Administration class that is registered in the Participant Pool.

Confidentiality:

- Responses to the survey cannot be anonymous for several reasons:
  - This survey will assess eligibility criteria for a follow-up study. In order for the researchers to know who met the eligibility criteria, they must be able to link your name to your survey responses. Additionally, researchers must be able to access your contact information to schedule an appointment for the follow-up study.
  - For those who choose to participate in the in-person follow-up study, some information collected on this survey will be analyzed in relation to performance in the follow-up study. Therefore, we need to be able to link your responses, and this requires that survey data is not anonymous.
- The link between your name/contact information and ID number will be stored on the participant pool, a secure and password protected website.
- In the documents and software used for analysis, your responses will be identified with a unique participant ID, rather than your name. These documents will be stored on password protected computers.
- To ensure confidentiality, your personal information will be absent, and responses will be aggregated, in the resulting theses, publications, and presentations. There will be no way to link any one person's responses to their identity.
- The Researchers, Supervisor, and Co-Supervisor are the only persons with access to your personal information and will employ the strictest rules of confidentiality.

Storage of Data:

- We collect data through the software Qualtrics, which uses servers with multiple layers of security to protect the privacy of the data (e.g., encrypted websites and password protected storage). Your data will be stored and protected by Qualtrics on Ireland-based servers but may be disclosed via a court order or data breach.
- Raw data will be downloaded onto a password protected computer that is stored in a locked room in the ARC lab. Once fully deidentified, the survey responses will be exported to OneDrive documents and statistical software for data analysis. OneDrive utilizes multiple layers of security to ensure protection of documents.
- All data will be stored for at least seven years, but no more than 10 years, following publication in a peer-reviewed journal article. When it is time to destroy the data, the data sheets, video recordings, and electronic data will be permanently deleted.

Right to Withdraw:

- Your participation is voluntary, and you are invited to only answer those questions that you are comfortable with. If you do not wish to answer one or more question(s), you can select the “Prefer not to answer” option or leave them blank (only applies to a few questions) to skip them.
- Should you wish to completely withdraw from the study, please close the browser window that the survey is open in.
- You may also choose to withdraw from the study after completing the survey. No explanation for withdrawal is required, and you can email any of the researchers listed on the first page and request that your data be deleted. Your right to withdraw data from the study will only apply for 1 week after you complete your survey. After this time, it is possible that some results have been analyzed, and it will not be possible to withdraw your data.
- There will be no penalty for withdrawing from this survey and you will still receive the extra course credit on your final grade. Should you choose to withdraw from the study, your responses will be permanently deleted before data analysis begins.

Follow up:

- Results of this study will be available by August 2025. If you would like to receive a summary of these results, you may request a copy from the Researchers or Supervisor. You are also welcome to access a summary of the results on the Supervisor’s website at www.arcresearch.ca.

Questions or Concerns:

- If you have any questions or concerns regarding this study, please contact the researchers using the information above.
- This project has been approved on ethical grounds by the University of Regina Research Ethics Board on July 23, 2025. Any questions regarding your rights as a participant may be addressed to the committee at (306-585-4775 or research.ethics@uregina.ca). Out of town participants may call collect.

Consent:

By completing and submitting the questionnaire, **YOUR FREE AND INFORMED CONSENT IS IMPLIED** and indicates that you understand the above conditions of participation in this study.

Appendix H

Study 2 Participant Consent Form

Project Title: The Interplay Between Psychosocial Factors and the Acute Stress Response: Psychological and Physiological Considerations (Part 2; An Experimental Study)

Researchers:

Ayesha Shafiq
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Dr. Natasha Gallant, PhD, RDPsych
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Assistant Professor, Department of Psychology
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natasha.gallant@uregina.ca

Co-supervisor:
Kelsey Haczkewicz, BA (Hons)
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ARC Research Unit
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Research Volunteers:
For each session, two research volunteers will be present. These individuals will see you while you are in the lab and, therefore, will know that you participated in the experiment but will not have access to any personal data or your responses to surveys.

Purpose and Objectives of the Research:

- You are invited to take part in this experiment because you have completed Part 1 of this study, indicated interest in participating in Part 2, and met the eligibility criteria.
- The current study aims to understand the impact of stress on physiological responses, mood, stress appraisal, and time perception.
- Results will be used as part of Honours thesis projects and in journal articles and conference presentations. Results from this study will also be shared on the ARC Research Unit website (www.arcresearch.ca) and X (Twitter), Instagram, and Facebook

(@ARCResearchUnit). Data obtained from this study may be used in future theses and/or publications.

Procedure:

- In this study, you will be scheduled a timeslot to come to a lab at the University of Regina in the Administration Humanities Building. The total time for your participation will take approximately 2 hours.
- You must be 18 years or older, reside in Canada, and be able to attend in-person to participate in this study.
- Upon arrival, we will set up various physiological monitoring equipment. This equipment will measure your heart rate, skin conductance, and facial movements. It is non-invasive but will require the researcher to make physical contact with you to set it up. We will collect physiological data throughout the experiment.
- You will also be asked to fill out questionnaires asking about your current mood, stress, and time perception. These questionnaires will be presented at multiple time points and collected using a tablet.
- After this, you will be given instructions to complete various tasks. These tasks will involve speaking to research personnel about yourself and answering skill-testing questions.
- Before, during, and after these tasks, your physiological response will be monitored.
- You will be video recorded during most of the study.
- Please feel free to ask any questions regarding the procedures and goals of the study or your role.

Funded by:

- The researchers each received financial support for their work on this project between May 2024 and August 2024 via an Undergraduate Student Research Award from the Natural Sciences and Engineering Research Council of Canada.

Potential Risks:

- It is possible that you may feel slight discomfort from physiological recording equipment, so let one of the researchers know if you need to take a break or are uncomfortable at any point during the study.
- Due to the nature of the tasks, it is possible that you may become distressed. If you become significantly distressed, as judged by researchers, we will automatically terminate your participation in the study. Additionally, at any point during your time in the lab, you have the right to ask that the study be terminated. We encourage you to do so if you feel significant and/or unmanageable distress.
- Following completion of the study, you will be debriefed and given the opportunity to ask questions.
- You will be given a list of mental health resources you can contact should you feel significant lingering distress following study completion.

Potential Benefits:

- Results from this study will contribute to the overall state of psychological knowledge by providing insight into stress and its relationship with several psychosocial and physiological factors.
- Please note that no personal benefits from participation are guaranteed, aside from receiving course credit for participating.

Compensation:

- Participants registered through the Psychology Participant Pool: In exchange for your participation, you will receive two bonus marks towards your final grade in a psychology class that is registered in the Participant Pool.
- Participants registered through the Business Participant Pool: In exchange for your participation, you will receive two bonus marks towards your final grade in a Business Administration class that is registered in the Participant Pool.

Confidentiality:

- Participant anonymity is limited as the researchers are also the experimenters and will be present during the in-person experiment. Additionally, the study's researchers will need to access your non-anonymous responses to the survey in Part 1 of this study in order to assess your eligibility and link your responses with those obtained during the experiment. Participant confidentiality will be protected as no link will be made between the data collected and participant identity in the resulting theses and publications.
- Your unique and confidential participant ID will be the only personal information collected in the surveys for this experiment.
- All physiological data will be linked to you only by your ID number.
- Your face will be visible in the video recordings, but the data collected from the videos will only be identified by ID number.
- The Researchers, Supervisor, and Co-Supervisor are the only persons with access to your personal information, data, and videos, and will employ the strictest rules of confidentiality.
- To ensure confidentiality, your personal information will be absent, and responses will be aggregated, in the resulting theses, publications, and presentations. There will be no way to link any one person's responses to their identity.

Storage of Data:

- We collect survey data through the software Qualtrics, which uses servers with multiple layers of security to protect the privacy of the data (e.g., encrypted websites and password protected storage). Your data will be stored and protected by Qualtrics on Ireland-based servers but may be disclosed via a court order or data breach.
- Raw data will be downloaded onto a password-protected computer that is stored in a locked room in the ARC lab. Once fully deidentified, the survey and physiological data will be exported to OneDrive documents and statistical software for data analysis. OneDrive is password-protected and utilizes multiple layers of security to ensure protection of documents.
- All video recordings will be securely stored by Dr. Natasha Gallant.
- All data will be stored for at least seven years, but no more than 10 years, following publication in a peer-reviewed journal article. When it is time to destroy the data, the data

sheets, video recordings, and electronic data will be permanently deleted.

Right to Withdraw:

- We hope that you will assist us with this study; however, your decision to participate is completely voluntary. You may withdraw from the study for any reason, at any time during the experiment, without explanation or penalty of any sort. You can withdraw during the experiment by letting a Researcher know that you would like to withdraw. Once you leave the lab, you will have up to 1 week to withdraw your data. You can do this by emailing one of the Researchers.
- If you do choose to withdraw, you will still receive full course credit.

Follow up:

- Results of this study will be available by August 2025. If you would like to receive a summary of these results, you may request a copy from the Researchers or Supervisor. You are also welcome to access a summary of the results on the Supervisor's website at www.arcresearch.ca.

Questions or Concerns:

- If you have any questions, or would like more information about the study, please contact the Researchers or Supervisors using the contact information at the beginning of this form.
- This project has been approved on ethical grounds by the University of Regina Research Ethics Board on (insert date). Any questions regarding your rights as a participant may be addressed to the committee at (306-585-4775 or research.ethics@uregina.ca). Out of town participants may call collect.

Consent:

Your signature below indicates that you agree with the following statements:

- I have read and understand the description provided above.
- I have had an opportunity to ask questions, and my questions have been answered.
- I consent to participate in the research project.
- I consent to being videotaped and for these videos to be analyzed by research personnel.
- A copy of this Consent Form has been given to me for my records.

______________________	______________________	____________
Name of Participant	*Signature*	*Date*
______________________	______________________	
Researcher's Signature	*Date*	

A copy of this consent has been sent to you, and this signed copy will be taken by the Researcher.

Appendix I

Study 2 Detailed Procedure

The following is the procedure for Group 1, in which participants complete the TSST and then the C-TSST. For Group 2, those who completed the C-TSST first then the TSST, it will be the same, just different order.

1. Orientation, consent, and equipment set-up (5 minutes)
2. Acclimation period (15 minutes)
    a. Start physiological measurements at the beginning of this period. Physiological measurements will be collected all throughout and will be timestamped between tasks.
3. Baseline measurements (5 minutes)
    a. STAI-State
4. Introduction to condition A or TSST (3 minutes)
5. Anticipation and speech preparation period (5 minutes)
6. Pre-task psychological measurements (2 minutes)
    a. STAI-State and Pre-task SAAS
7. Brief task reminder (2 minutes)
8. Speech task (5 minutes)
9. Arithmetic task (5 minutes)
10. Post-task measurements (2 minutes)
    a. STAI-State and Pre-task SAAS
11. Recovery period (8 minutes)
12. Post-recovery measurements (2 minutes)
    a. STAI-State
13. Acclimation period (5 minutes)
14. Baseline measurements (5 minutes)
    a. STAI-State
15. Introduction to condition B or C-TSST (3 minutes)
16. Anticipation and speech preparation period (5 minutes)
17. Pre-task psychological measurements (2 minutes)
    a. STAI-State and Pre-task SAAS
18. Brief task reminder (2 minutes)
19. Speech task (5 minutes)
20. Arithmetic task (5 minutes)
21. Post-task measurements (2 minutes)
    a. STAI-State and Pre-task SAAS
22. Recovery period (8 minutes)
23. Post-recovery measurements (2 minutes)
    a. STAI-State
24. Debriefing (10 minutes)

Appendix J

Study 1 Debriefing and Mental Health Resources

Thank you for participating in this research study! Please note, after reading this debriefing, <u>you must advance to the next page</u> by selecting "Next Page" at the bottom right in order to receive your course credit.

As said in the consent form, the primary objective of this survey was to investigate the relationships between different psychosocial variables. Throughout this survey, a range of topics were assessed, including adverse childhood experiences, adulthood social support, emotion regulation, perspectives on time, anxiety, and social factors. The researchers aim to understand the associations between these factors, gaining insight into how they influence each other.

Events and experiences in your early life that may have been stressful and traumatic were explored by assessing adverse childhood experiences. By gaining insight into these experiences, the researchers can analyze the long-term impact they may have had on one's well-being. Emotion regulation, one's ability to manage and respond to emotions as needed in various social situations, was then assessed. Along with social support, which was examined by investigating the network of people you surround yourself with and feelings of social isolation, the survey asked you about your social interactions and experiences. Perspectives on time, which can also influence various aspects of life, were assessed by looking at your ability to perceive and relate to time, including understanding your views on the past, present, and future. Anxiety was then assessed as it is another common psychological experience that can influence one's quality of life and interactions with those around them.

By identifying the associations between these psychosocial variables, researchers can understand the pathways through which different aspects of experiences interact and influence each other. If at any time you have questions or concerns regarding the study or your participation, please reach out to the researchers, Carissa Melnyk (Carissa.Melnyk@uregina.ca), Ayesha Shafiq (Ayesha.Shafiq@uregina.ca), or Briana De Roo (Briana.DeRoo@uregina.ca). If you have any concerns about your rights as a participant in this study, you may also contact the Research Ethics Board (306-585-4775 or research.ethics@uregina.ca).

As a reminder, if you experienced significant distress during or following your participation in this study, we encourage you to call your local crisis helpline or emergency department, or access the resources below. Thank you again for your participation in this study!

Regina Mobile Crisis Services
Location: 1646 11th Avenue, Regina
Phone: 306-757-0127 (mobile crisis helpline) or 306-525-5333 (crisis suicide helpline)
Email: ecounselling@mcsregina.ca
https://mobilecrisis.ca/

Counselling Services – University of Regina
Location: Room 251 Riddell Centre

Phone: 306-585-4491
Email: counselling.services@uregina.ca
https://www.uregina.ca/student/counselling/

Mental Health Clinic
Location: 3rd Floor, 2110 Hamilton Street, Regina
Phone: 306-766-7800

Suicide Crisis Helpline Canada
Phone: 988
Text: 988
https://988.ca/

Instructions on how to save this page as a PDF

For Internet Explorer, Firefox, or Google Chrome:
Select “Print” or press Ctrl + P to Save as PDF

For Safari:
File to Print to Select PDF (icon on lower left-hand corner) to Save as PDF
OR
Press Command + P to Select PDF (icon on lower left-hand corner) to Save as PDF

Appendix K

Study 2 Debriefing

The following is the debriefing for Group 1, in which participants complete the TSST and then the C-TSST. For Group 2, those who completed the C-TSST first then the TSST, it will be the same, just different order.

"Today, you have completed two different experimental conditions. The first one was called the Trier Social Stress Test. It consisted of a pretend job interview and surprise difficult math task. This test is specifically designed to elicit psychological stress inside a lab environment. These tasks were intentionally difficult and do not in any way reflect upon your aptitude or ability. The panel members, who are not trained in non-verbal behaviour, were not evaluating or scoring you at all today and no video analysis on performance will be conducted either. These measures were all prop elements designed to induce stress. We will not be comparing your performance to any other participants. The second part of the experiment today was a control version of the Trier Social Stress Test. This consisted of the speech on a book, movie, or holiday trip followed by the easy math task. These tasks were designed to be a non-stressful comparison to the stressful condition. As mentioned during the task, the purpose of the speech and math test was not to evaluate your performance. It was simply to have you do non-stressful tasks that were comparable in physical demand to the stressful tasks completed earlier. What we were actually measuring today was the effects of stress on heart rate, skin conductance, facial movement, anxiety, time perception, mood, and stress appraisals. To do this, we needed to test you on these variables during a stressful and non-stressful task. We apologise for not being completely honest about everything throughout the testing session, but we required the stress test to feel real or it would not be as stressful. It is really important that you do not disclose the events that took place during this study to anyone who might potentially participate. If you tell someone that we had you complete a job interview speech and difficult math task, and then they decide they want to participate in the study, they will not be surprised by the task and therefore will not be adequately stressed to accurately represent a typical person's stress response. This would compromise the quality of our research. [pause] You have done a really good job today and we really appreciate your effort and participation. Do you feel okay about everything? [allow participant to answer] Are you okay with us using the information we have acquired from you today for analysis? [allow participant to answer] Are there any questions you would like to ask us? [allow participant to ask questions and answer them as needed] Here is a pamphlet with mental health resources should you feel any lingering significant distress following the experiment today [hand them the pamphlet]."

Appendix L

Mental Health Resources

As a reminder, if you experienced significant distress during or following your participation in this study, we encourage you to call your local crisis helpline or emergency department or access the resources below. Thank you again for your participation in this study!

Regina Mobile Crisis Services
Location: 1646 11th Avenue, Regina
Phone: 306-757-0127 (mobile crisis helpline) or 306-525-5333 (crisis suicide helpline)
Email: ecounselling@mcsregina.ca
https://mobilecrisis.ca/

Counselling Services – University of Regina
Location: Room 251 Riddell Centre
Phone: 306-585-4491
Email: counselling.services@uregina.ca
https://www.uregina.ca/student/counselling/

Mental Health Clinic
Location: 3rd Floor, 2110 Hamilton Street, Regina
Phone: 306-766-7800

Suicide Crisis Helpline
Phone: 988
Text: 988
https://988.ca/

If at any time you have questions or concerns regarding this study or your participation, please reach out to the researchers, Carissa Melnyk (Carissa.Melnyk@uregina.ca), Ayesha Shafiq (Ayesha.Shafiq@uregina.ca), or Briana De Roo (Briana.DeRoo@uregina.ca). If you have any concerns about your rights as a participant in this study, you may also contact the Research Ethics Board (306-585-4775 or research.ethics@uregina.ca).

Appendix M

30-Second Interval Selection Criteria for EDA and ECG Data

EDA data was clean for all participants so ECG data was used to decide which 30-second interval would be best. If the interval chosen still had noise associated with it, experimenter would clean it before exporting the results for analysis.

<u>ECG and EDA DATA</u>

Baseline

- Cleanest 30 seconds within the last minute

Anticipation

- Cleanest 30 seconds within +10 to +70 seconds

Speech

- Cleanest 30 seconds within +30 to +90 seconds

Math

- Cleanest 30 seconds within +30 to +90 seconds

Recovery

- Cleanest 30 seconds from +390 to +450 seconds (within last 90 seconds, excluding the very last 30 seconds)

<u>EDA DATA ONLY</u>

Baseline

- First 30 seconds within the last minute

Anticipation

- +10 to +40 seconds

Speech

- +30 to +60 seconds

Math

- +30 to +60 seconds

Recovery

- +390 to +420 seconds (first 30 seconds within last 90 seconds)

Appendix N

Research Ethics Board Approval

[Converis] REB Application #843 The Interplay Between Psychosocial Factors and the Acute Stress Response: Psychological and Physiological Considerations

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From research.ethics@uregina.ca <research.ethics@uregina.ca>
Date Tue 7/23/2024 5 32 PM
To Ayesha Shafiq <Ayesha.Shafiq@uregina.ca>

Research Ethics Board (REB): Application # 843
Title: The Interplay Between Psychosocial Factors and the Acute Stress Response: Psychological and Physiological Considerations
Approval Date: 23-Jul-2024
Renewal Date: 23-Jul-2025
PI: Natasha Gallant
PI: Ayesha Shafiq
PI: Carissa Melnyk
PI: Briana De Roo

The University of Regina Research Ethics Board has reviewed the above-named research project. The proposal was found to be acceptable on ethical grounds. The principal investigator has the responsibility for any other administrative or regulatory approvals that may pertain to this research project, and for ensuring that the authorized research is carried out according to the conditions outlined in the original protocol submitted for ethics review. This Certificate of Approval is valid for the above time period provided there is no change in experimental protocol, or related documents.

Any significant changes to your proposed method, procedures or related documents should be submitted as an amendment for Research Ethics Board consideration in advance of implementation.

Jennifer Gordon
Research Ethics Board Chair
University of Regina