Highlights

- Our previous work showed how brief self-compassion training reduced stress response
- We examine psychological trait predictors and moderators of these effects
- We focused on salivary alpha amylase and subjective anxiety responses to the Trier
- Trait non-attachment, rumination, and social anxiety moderated Trier responses
- Trait self-compassion did not moderate or predict Trier responses
- Findings suggest the role of psychological traits in moderating Trier responses
Predictors and moderators of biopsychological social stress responses following brief self-compassion meditation training

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Abstract

Arch et al (2014) demonstrated that brief self-compassion meditation training (SCT) dampened sympathetic (salivary alpha-amylase) and subjective anxiety responses to the Trier Social Stress Test (TSST), relative to attention and no-instruction control conditions. The present study examined baseline predictors and moderators of these SCT intervention effects. Baseline characteristics included two stress vulnerability traits (social anxiety and rumination) and two potential resiliency traits (non-attachment and self-compassion). We investigated how these traits moderated SCT response to the TSST relative to the control conditions. We also tested how these individual differences predicted TSST responses across conditions in order to uncover characteristics that confer increased vulnerability and resiliency to social stressors. Trait non-attachment, rumination (for sympathetic TSST response only), and social anxiety (for subjective TSST response only) interacted with training condition to moderate TSST responses such that following SCT, lower attachment and lower social anxiety predicted lower TSST stress responses, relative to those scoring higher on these traits. In contrast, trait self-compassion neither moderated nor predicted responses to the TSST. Thus, although SCT had robust effects in buffering stress across individuals with varying levels of trait self-compassion, other psychological traits enhanced or dampened the effect of SCT on TSST responses. These findings support the importance of examining the role of relevant baseline psychological traits to predict sympathetic and subjective responses to social evaluative threat, particularly in the context of resiliency training.

Keywords: Self-compassion; meditation; stress; social evaluative threat; alpha-amylase; social anxiety
1. Introduction

1.1 Background

There has been a growing interest in interventions that promote resilience to social stress. For example, intensive stress management (Hammerfeld et al., 2006) and personal values affirmation (Creswell et al., 2005) have been shown to dampen cortisol responses to the Trier Social Stress Task (TSST) (Kirschbaum, Pirke, & Hellhammer, 2008), which reliably evokes a cortisol response (Dickerson & Kemeny, 2004). Contemplative interventions also have shown promise in promoting resilience. For example, Arch et al. (2014) found that brief self-compassion meditation training diminished sympathetic nervous system (salivary alpha amylase) and subjective anxiety responses to the TSST among women.

Yet even following training, individuals differ in response to the same social stressor (Chida & Hamer, 2008). This question of for whom interventions are effective is longstanding in medicine and psychology (e.g., Norcross & Wampold, 2011). With several exceptions (e.g., Creswell et al., 2014; Hammerfeld et al, 2006), little research has examined how individual differences can moderate social stress resilience training outcomes. The present study assessed such boundary conditions, using self-compassion training (SCT) as a model; this training has shown considerable promise in boosting social stress resilience (e.g., Arch et al, 2014; Pace et al, 2009; Leary et al., 2007). Specifically, Arch et al. (2014) showed that SCT, consisting of a brief lovingkindness or metta meditation practiced everyday for three days and again prior to receiving the TSST instructions, resulted in lower salivary alpha-amylase (sAA) and state anxiety in response to the TSST than attention-control and no intervention control conditions1. The current study represents a secondary

1 Of note, our metta meditation-based approach to SCT differs from the more intensive mindful self-compassion training program developed by Neff and Germer (2013) as well as the traditional Tibetan mind-training practices (lojong) studied by Pace et al (2009).
analysis of Arch et al (2014) in which we assess for whom SCT is most beneficial - that is, we explore the boundary conditions of the original findings.

In asking for whom SCT is most likely to be beneficial, we put forth competing hypotheses: One possibility is that a predisposition toward self-compassion, reflected in higher trait self-compassion, will lead to greater benefit from SCT because self-compassion can be taught more readily to those already higher in this trait (Gilbert et al., 2011); a competing possibility is that those lower in trait self-compassion will stand to benefit the most from SCT because they have more room to increase in self-compassion (and a greater need for such training; e.g., Gilbert & Procter, 2006). Further, theory and research (Sahdra, Shaver, & Brown, 2010) suggest that higher non-attachment, reflecting less fixation on achieving particular outcomes, would predispose to lower TSST stress-related emotional and neuroendocrine outcomes and that this predisposition might be potentiated by training in self-compassion. Conversely, we hypothesized that following SCT, higher trait social anxiety and rumination would predict higher social stress reactivity within this condition (Condren et al., 2002; Young & Hoeksema, 2001) relative to lower trait social anxiety and rumination, as these dispositions appear to reflect less openness to key SCT elements (Gilbert et al., 2011), potentially reducing training impact.

1.2 The Present Research

Extending Arch et al. (2014)’s investigation of SCT, we investigated how these four baseline characteristics differentially predict SCT response to the TSST relative to two control conditions. Secondarily, we tested how these individual differences predict TSST responses across conditions to uncover characteristics that confer increased vulnerability and resilience to social stressors. Salivary cortisol, reflecting HPA axis activity, is a commonly studied neuroendocrine marker of TSST response. However, sympathetic nervous system activity markers, particularly the protein salivary alpha amylase (sAA),
have shown sensitivity to TSST demands (Nater et al., 2006), and Arch et al. (2014) found that this outcome, along with subjectively-experienced emotion, showed particular responsiveness to SCT. Investigations of sAA response to the TSST are growing (see Nater & Rohleder, 2009), and generally suggest that lower sAA levels correspond with lower stress levels (both perceived and objective stress). In accord with this, in our original investigation (Arch et al., 2014), the SCT group showed the lowest sAA as well as the lowest subjective anxiety levels in response to the TSST, relative to active and passive conditions. Thus, in studying the boundary conditions of the significant effects of SCT on sAA and subjective anxiety TSST responses in the Arch et al. (2014) study, the present study examined how the four traits of interest predicted these two TSST outcomes.

2. Material and methods

2.1 Participants

One hundred five physically healthy undergraduate women reporting no medication or oral contraception use completed the TSST; seven were excluded due to missing outcome data. Women received course credit or payment. IRB approval and informed consent were obtained. See Arch et al. (2014) for further details.

2.2 Experimental conditions

Participants were randomized to SCT, attention (placebo) control, or no intervention. SCT used recorded 10-minute self-focused lovingkindness meditations to cultivate self-kindness/compassion. The attention control used recorded 10-minute excerpts from a cognitive psychology textbook used to control for attention and placebo effects of listening to a recording with content plausibly relevant to TSST preparation, including discussions of problem solving, judgment, and thinking (see Arch et al., 2014). No recordings were used in the no-intervention condition to provide a control condition that allowed for a “natural” response to the TSST without intervention, to compare to the effects
of SCT. To reflect the statistical approach in the original paper and reduce the need for post-hoc condition testing (Arch et al., 2014), we retained the a priori contrast codes that compared a) each control condition, to confirm a lack of difference between the two control conditions. This variable was labeled “Group 1”; and b) the control conditions to the SCT condition. This variable was labeled “Group 2” and represented the contrast code of interest. However, both contrast codes were included in all analyses, thereby accounting for differences between the two control conditions when examining the difference between the control conditions and the SCT condition.

2.3 Design and Procedures

Two sessions were scheduled 4 days apart. In session 1 (s1), individual difference measures (below) were completed. Those in the self-compassion and attention control conditions were introduced to a 10-minute, condition-specific recording and instructed to attentively listen to a “similar recording” accessed via a secure website daily for the next 3 days. Session 2 (s2; TSST session) was scheduled between 1-6 pm. Following a 30 min baseline period participants were told: “The rest of the study will be challenging.” Women in the active conditions were additionally told, “To help you prepare for the challenge, we invite you to listen to a recording similar to the ones you listened to at home,” followed by a 5-minute condition-specific recording. TSST followed canonical procedures (Kirschbaum et al., 2008), excepting a 5-min (rather than 10-min) speech anticipation period.

2.4 Measures

2.4.1 Individual differences

Self-compassion was assessed with the validated, 26-item Self-Compassion Scale (SCS; Neff, 2003), measuring tendencies to be kind toward oneself, connected to a common sense of humanity, and mindfully aware of painful thoughts and feelings (current study α = .94).
Non-attachment was measured with the 30-item Non-attachment Scale (NAS; Sahdra et al., 2010; example item: “I can accept the flow of events in my life without hanging onto them or pushing them away.”). The NAS has strong convergent and discriminant validity and one month test-retest reliability (r = .87); study α = .92.

Social Anxiety during social interactions was assessed with the well-validated, 20-item Social Interaction Anxiety Scale (SIAS; Mattick and Clarke, 1998); study α = .92. The SIAS was square root transformed to normalize its distribution prior to analysis.

Rumination was assessed with the 12-item rumination subscale of the Rumination Reflection Questionnaire (RRQ; Trapnell & Campbell, 1999); study α = .91.

2.4.2 TSST outcomes

Salivary Alpha Amylase (sAA): Saliva was collected at five points during s2: baseline, immediately post-TSST, 10 min post-TSST, 20 min post-TSST, and 35 min post-TSST. However, sAA levels returned to baseline by 20 min post-TSST (see Arch et al, 2014) as sAA is known to react and recover more quickly than cortisol (Rohleder et al, 2004; Nater et al, 2005). Thus, we focused analyses on the first four sAA collection points (baseline to 20 min post-TSST). Samples were stored in a -15°C freezer; all samples from the same subject were processed in the same assay. Samples were assessed by kinetic assay (Salimetrics; State College, PA) and run in singlet, diluted 1:200. Inter- and intra-assay coefficients of variability for sAA samples were 4.7 and 11.3%, respectively.

State Anxiety: The widely-used Subjective Units of Distress Scale (SUDS; Wolpe, 1990) assessed state anxiety on a 0-100 scale, at the same points as sAA plus one additional time during the TSST preparation period. Thus, to match the time frame of the sAA analyses and capture the period of greatest SUDS reactivity and recovery, we focus on the SUDS ratings from baseline to 20 min post-TSST.
2.5 Statistical Approach

We constructed hierarchical linear models in HLM 7.0 to model time-varying outcomes and random effects. We included linear and quadratic terms at level 1 to capture linear and curvilinear responses of sAA and SUDS to the TSST. A priori contrast coding was used to compare the two control conditions to the self-compassion condition. All putative moderators were centered prior to entry in the model or computation of interaction terms. As presented in Table 1, the putative trait moderators, assessed at baseline, and the trait x condition interactions were included at level 2 of each model. As recommended when examining higher order interactions, all lower order main effects and interactions were included in the model. Although this necessitated including many lower order terms, we focused on those that directly tested our hypotheses. Thus, the primary moderator term of interest was the higher order (quadratic) time x trait x Group 2 interaction (see Table 1), which indicated whether SCT, relative to the two control conditions, produced a significantly different curvilinear pattern of change in sAA or SUDS in response to the TSST. We were also interested in the trait x Group 2 interaction on the intercept, which, in the absence of interaction with time, would indicate a stable difference in the influence of the trait moderator on TSST responses between the SCT versus control conditions. If the putative moderator interactions were non-significant, the model was recalculated without them to test whether the putative moderator instead served as a predictor, that is, whether it affected TSST response across condition. For this prediction analysis, the predictor x quadratic time interaction represented the key effect of interest, indicating that the predictor influenced the curvilinear rate of change in TSST responses (c.f. Brown, Weinstein & Creswell, 2012).

3. Results
Moderator and predictor findings

Trait self-compassion neither moderated intervention condition effects on sAA or SUDS at any time point, nor did trait self-compassion predict sAA responses across conditions, $p > .16$. However, higher trait self-compassion predicted lower SUDS ratings at the intercept, $b = -.20$, $p = .01$, suggesting a main effect of trait self-compassion across condition that did not differ significantly by assessment point.

The non-attachment x Group 2 x quadratic time interaction was significant in predicting sAA, $b = -.01$, $p = .02$, indicating that non-attachment moderated the intervention condition effect on sAA in a curvilinear manner over time. Figure 1a shows that non-attachment levels predicted sAA responses more in the SCT than control groups, reflecting a pattern such that those higher in non-attachment (less attached) in the SCT condition showed the lowest sAA reactivity and fastest sAA recovery among the participants, whereas those lower in non-attachment (more attached) in the SCT condition showed higher overall sAA levels throughout. In contrast, non-attachment levels did not influence response in the control conditions to the same extent as in the SCT (e.g., both more and less attached control participants showed a similar level of sAA and arc of sAA reactivity and recovery). The same non-attachment x Group 2 x quadratic time interaction significantly predicted SUDS, $b = .04$, $p = .04$, with a similar pattern of intervention condition by trait differences. As illustrated in Figure 1b, levels of non-attachment played a greater role among SCT trainees, such that those higher in non-attachment (less attached) showed the lowest levels of SUDS reactivity among participants whereas those lower in non-attachment (more attached) showed higher levels of SUDS throughout. In contrast, both more and less attached control group participants showed a similar level and arc of TSST response.

Social anxiety did not moderate the impact of SCT on the cascade of sAA responses
to the TSST; that is, the interaction of social anxiety x Group 2 x quadratic time was non-significant, $b = .00$, $p = .99$. However, examining social anxiety as a predictor of sAA across conditions revealed an interaction of social anxiety with quadratic time, $b = .06$, $p = .04$, such that higher levels of social anxiety predicted lower sAA responses at immediate post-TSST, as illustrated in Figure 2a. For SUDS responses to the TSST, the interaction of social anxiety x Group 2 x quadratic time also was non-significant, $b = -.11$, $p = .42$. However, there was an overall social anxiety x Group 2 interaction (on the intercept term, see Table 1 and Figure 2b), $b = 1.48$, $p = .04$, with the pattern showing that social anxiety influenced overall SUDS levels to a greater extent in the SCT condition than in the control conditions. Thus, SCT participants with lower social anxiety levels showed the lowest levels of SUDS reactivity to the TSST whereas SCT participants with higher social anxiety levels showed higher SUDS throughout (though a pattern of lower increase from baseline to peak SUDS, compared to the control conditions).

*Rumination* moderated the effect of intervention condition on curvilinear change in sAA in response to the TSST, that is, the rumination x Group 2 x quadratic time interaction was significant, $b = .01$, $p = .01$. Figure 3 shows that those lower in rumination demonstrated lower sAA during recovery from the TSST and that this effect was more pronounced in the control condition at 10 minutes recovery (reflecting a pattern of slower initial recovery among high rumination controls relative to low rumination controls). Although those higher and lower in rumination within the SCT condition diverged at 20 minutes (final) recovery, this appears to reflect the fact that the higher rumination SCT group showed higher baseline levels of sAA (but not slower recovery to baseline). Rumination neither moderated the intervention effect nor predicted curvilinear change in SUDS responses to the TSST, $ps > .56$. Rather, higher rumination predicted higher SUDS throughout the session, without respect to assessment point or condition; that is, the main
effect of rumination on the intercept was significant, \( b = .52, p = .005 \).

4. Discussion

This is one of the few studies to examine putative baseline psychological trait moderators of the effect of resiliency training on TSST responses and the first to examine moderators of self-compassion training in this context. Additionally, it only the second known study (c.f., Maruyama et al., 2012) to explore cross-condition trait prediction of sAA response to the TSST. The findings largely confirmed our hypotheses that baseline traits would moderate training effects on sympathetic (sAA) and subjective anxiety (SUDS) responses to the TSST.

The influence of several traits on sAA and subjective anxiety responses to the TSST were more pronounced following self-compassion training than following the control conditions. Specifically, non-attachment, a resiliency trait, influenced sAA and subjective anxiety responses to the TSST more in the SCT than the control conditions, such that those who received SCT and were higher in non-attachment (less attached) showed the most resilient response profiles of all participants, with a pattern of lower sAA and subjective anxiety responses to the TSST (either at immediate post-TSST or during recovery). Similarly, social anxiety levels influenced subjective anxiety responses to the TSST more in the SCT than control conditions, such that those who received SCT and were lower in social anxiety showed the lowest subjective reactivity to the TSST, relative to the higher subjective anxiety responses reported by those in SCT who were higher in social anxiety. In contrast, control participants who were high or low in non-attachment or social anxiety (the latter, for subjective anxiety responses only) did not differ as much on their responses to the TSST. This suggests that lower attachment and social anxiety levels potentiated the effects of SCT such that those who expressed more optimal levels of these traits at baseline (higher non-attachment and lower social anxiety) benefitted more from SCT than those with less optimal
levels of these traits. Thus, thus, not everyone benefitted from SCT similarly. In light of the brief nature of SCT offered in the current study, participants with less optimal levels of these traits may require more intensive or tailored self-compassion training in order to realize similar benefits as those with more optimal levels.

In contrast, the influence of rumination on sAA responses was somewhat more pronounced in the control conditions than the SCT condition. Thus, participants higher versus lower on rumination in the control conditions diverged more during early recovery than those in the SCT; in contrast, participants higher in rumination in the SCT condition showed higher baseline sAA levels but a pattern of lower peak from baseline and faster recovery to baseline following the TSST, relative to those higher in rumination in the control conditions. Thus, compared to the control conditions, SCT appears to have particularly benefitted those higher in rumination from the perspective of facilitating a faster return to baseline, albeit a high baseline.

Social anxiety and rumination have known impacts on post-event processing and recovery from stressful social events (Condren et al., 2002; Young & Nolen-Hoeksema, 2001), and this study suggests that these traits influence the effects of self-compassion training. Conversely, non-attachment, a novel construct in psychobiological science, benefited SCT outcomes, findings that support further study of this trait in resiliency research. Notably, these trait moderations of sAA and anxiety were not statistically large, suggesting that SCT had relatively robust effects on these outcomes (see Arch et al., 2014) even after accounting for SCT-relevant resilience and vulnerability traits.

Interestingly, while higher trait self-compassion predicted lower SUDS anxiety, but not sAA, across time, it did not amplify (moderate) the effects of SCT. This is not consistent with the amplification of mindfulness training on social stress responses afforded by trait mindfulness (Creswell et al., 2014), and suggests that SCT is appropriate even for
individuals without the dispositional predilection towards it. Further, the relationship of social anxiety levels and sAA responses were inconsistent with other findings, in that higher social anxiety levels (across groups) predicted lower sAA increases in immediate response to the TSST. Thus, further investigation is needed to assess the contexts under which lower sAA responses to the TSST reflect more or less optimal levels of a trait.

Conclusion

The present findings represent one of the few investigations that address for whom resilience enhancement interventions buffer psychological and sympathetic social stress responses. Most examined traits interacted with condition to predict subjective or sAA responses to the TSST. Thus, findings indicated potential boundary conditions for brief SCT among young women, such those higher in social anxiety or attachment benefitted less than those with lower levels of these traits; yet women with higher or lower levels of trait self-compassion benefitted similarly. These findings support further study of the important question of for whom resiliency training in general, and self-compassion training in particular, benefits most.
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All authors helped to conceptualize the study, J. J. A. and L. N. L. conducted the data analyses, L. N. L. drafted the original paper with input from J. J. A. and K. W. B., and J. J. A. extensively revised the paper with input from L. N. L. and K. W. B. All authors approved the final version.
References


Figure Captions

Figure 1a. Moderation of salivary alpha-amylase response to the TSST by a non-attachment x condition x time interaction (±1SE; \( p = .02 \)). Non-attachment predicted sAA responses to a greater extent in the SCT than control groups, such that those higher in non-attachment in the SCT group showed the lowest sAA reactivity and fastest recovery, whereas those lower in non-attachment in the SCT condition showed higher overall sAA levels.

Figure 1b. Moderation of subjective anxiety (SUDS) response to the TSST by a non-attachment x condition x time interaction (±1SE; \( p = .04 \)). Non-attachment played a greater role in the SCT than control groups; those scoring higher in non-attachment showed lower levels of SUDS reactivity relative to those lower in non-attachment in SCT. In contrast, both more and less attached control participants showed a similar level and arc of SUDS response to the TSST.

Note: SCT = Self-Compassion Training; non-att = trait non-attachment; sAA = salivary alpha amylase; SUDS = Subjective Units of Distress Scale; TSST = Trier Social Stress Task

Figure 2a. Prediction of salivary alpha-amylase response to the TSST by a social anxiety by time interaction (±1SE; \( p = .04 \)). Higher levels of social anxiety predicted a different arc of sAA responses, driven by lower sAA immediately following the TSST.

Figure 2b. Moderation of subjective anxiety (SUDS) response to the TSST by a social anxiety by condition interaction (±1SE; \( p = .04 \)). Higher social anxiety predicted higher overall SUDS levels to a greater extent in the SCT condition than in the control conditions.

Note: SCT = Self-Compassion Training; non-att = trait non-attachment; sAA = salivary alpha amylase; SUDS = Subjective Units of Distress Scale; TSST = Trier Social Stress Task

Figure 3. Moderation of salivary alpha amylase response to the TSST by a rumination x condition x time interaction (±1SE; \( p = .01 \)). Those lower in rumination had lower sAA during TSST recovery compared to those higher in rumination; this effect was more pronounced in the control condition (reflecting slower post-TSST recovery among high rumination control participants).

Note: SCT = Self-Compassion Training; rum = trait rumination; sAA = salivary alpha amylase
Tables

Table 1. *Variables Included in HLM Moderator Analyses (on Level 2)*

<table>
<thead>
<tr>
<th>Trait Predictor/ Moderator</th>
<th>Variables included in the model (for each sAA and SUDS rating outcomes)</th>
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</table>
| 1. Self-compassion          | * Intercept:  
|                             | Group1  
|                             | Group2*  
|                             | Self-compassion*  
|                             | Self-compassion x Group1  
|                             | Self-compassion x Group2  
|                             | * Linear slope:  
|                             | TIME x Self-compassion  
|                             | TIME x Group1  
|                             | TIME x Group2*  
|                             | TIME x Self-compassion x Group1  
|                             | TIME x Self-compassion x Group2  
|                             | ° Quadratic slope:  
|                             | TIME^2 x Self-compassion  
|                             | TIME^2 x Group1  
|                             | TIME^2 x Group2*  
|                             | TIME^2 x Self-compassion x Group1  
|                             | TIME^2 x Self-compassion x Group2 |
| 2. Non-attachment           | * Intercept:  
|                             | Group1  
|                             | Group2*  
|                             | Non-attachment*  
|                             | Non-attachment x Group1 °  
|                             | Non-attachment x Group2  
|                             | ° Linear slope:  
|                             | TIME x Non-attachment  
|                             | TIME x Group1  
|                             | TIME x Group2* °  
|                             | TIME x Non-attachment x Group1  
|                             | TIME x Non-attachment x Group2* °  
|                             | ° Quadratic slope:  
|                             | TIME^2 x Non-attachment  
|                             | TIME^2 x Group1  
|                             | TIME^2 x Group2 °  
<p>|                             | TIME^2 x Non-attachment x Group1 |</p>
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<th>3. Social anxiety</th>
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<td>( \text{TIME} \times \text{Social anxiety} \times \text{Group2} )</td>
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<td><strong>Quadratic slope:</strong></td>
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*indicates \( p < .05 \) finding for the SUDS outcome; \( ^{\circ} \)indicates \( p \leq .05 \) for the sAA outcome
Note: The main effects of interest were the TIME$^2$ x Trait x Group2 moderator effect and if nonsignificant, then the TIME$^2$ x Trait predictor effect. All trait variables were centered prior to entering them into the model as main effects and prior to creating the interaction terms. Group 1 = contrast code 1 in which the attention control was compared to the no-instruction control group, Group 2 = contrast code 2 in which the self-compassion training group was compared to the control groups.
Figure 1a. Moderation of salivary alpha-amylase response to the TSST by a non-attachment x condition x time^2 interaction (±1SE; \( p = .02 \)).

Figure 1b. Moderation of subjective anxiety (SUDS) response to the TSST by a non-attachment x condition x time^2 interaction (±1SE; \( p = .04 \)).

*Note: SCT = self-compassion training; non-att = trait non-attachment; sAA = salivary alpha amylase; SUDS = subjective units of distress scale*
Figure 1a.

Figure 1b.
Figure 2a. Prediction of salivary alpha-amylase response to the TSST by a social anxiety by time^2 interaction (±1SE; p = .04).

Figure 2b. Moderation of subjective anxiety (SUDS) response to the TSST by a social anxiety by condition interaction (±1SE; p = .04).

Note: SCT = self-compassion training; soc = social anxiety; sAA = salivary alpha amylase; SUDS = subjective units of distress scale
Figure 2a.

Figure 2b.
Figure 3. Moderation of salivary alpha amylase response to the TSST by a rumination x condition x time\(^2\) interaction (±1SE; \(p = .01\)).

*Note:* SCT = self-compassion training; rum = trait rumination; sAA = salivary alpha amylase
Figure 3.