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The effect of self-referential processing on anxiety in response to naturalistic and laboratory stressors

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ABSTRACT

Although stressful life events increase risk for symptoms of Generalised Anxiety Disorder (GAD), we know little about mechanisms that increase GAD symptoms during times of stress. Despite evidence that self-referential processing contributes to other forms of psychopathology, namely depression, it is unknown whether self-referential processing also contributes to symptoms of GAD. Thus, we examined the association of self-referential processing with GAD symptoms in response to a naturalistic stressor (Study 1; n=135) and with anxiety-tension in response to a laboratory stressor (Study 2; n=56). In Study 1, participants completed the self-referential encoding task (SRET) in their initial weeks of university, and we assessed GAD symptoms four times across the semester. In Study 2, participants completed the SRET immediately before a laboratory stressor, and we assessed moment-to-moment changes in anxiety-tension. Greater negatively biased self-referential processing was associated with higher GAD symptoms at the start of university and greater reactivity to the laboratory stressor. In contrast, greater positively biased self-referential processing served as a protective factor associated with greater decline in symptoms over time. This study is the first to demonstrate that there are valence-specific effects of self-referential processing on anxiety, suggesting that self-referential processing may be relevant to GAD.

Anxiety disorders represent the most common class of mental illness. In fact, approximately one-third of adults report clinically significant symptoms of anxiety (Kessler et al., 2012), of which symptoms of generalized anxiety disorder (GAD) are among the most common (Wittchen et al., 2002). GAD is a disorder characterised by excessive and uncontrollable worry and anxiety that results in physiological symptoms, the most discriminative of which is muscle tension (Joormann & Stober, 1999; Pluess et al., 2009). GAD is associated with significant impairment in work, social relationships, and physical health that decreases individuals' quality of life (Henning et al., 2007). Given the high prevalence and significant functional impairments associated with GAD, it is critical to identify factors associated with elevations in GAD symptoms.

In this context, researchers have theorised that stressful life events can precipitate the development and exacerbation of anxiety symptoms (Barlow, 2002; Mineka & Zinbarg, 2006). Mineka and Zinbarg (2006), for example, proposed that individuals who experience unpredictable and uncontrollable life stressors are particularly vulnerable to symptoms of GAD. Surprisingly, however, there is a relative paucity of research that examines the role of stressful life events in anxiety disorders (Uliaszek et al., 2010), and little is known about vulnerability factors that predict individual differences in GAD symptoms during times of stress.

Cognitive models have been instrumental in informing our understanding of the etiology, exacerbation, and treatment of psychopathology in general (Beck & Haigh, 2014) and generalized

anxiety disorder in particular (Beck et al., 1985; Wells, 1999). Cognitive models of psychopathology point to negatively biased self-referential processing as a critical risk factor for psychopathology. Self-referential processing indexes an individual's underlying self-schemas, one's internal representation of themself. Cognitive models of psychopathology posit that self-schemas are pre-existing diatheses that remain latent until activated by mild negative mood states, and in turn, predict how individuals respond to and recover from stress (Beck & Haigh, 2014). As such, self-referential processing has been conceptualised as an important individual-difference factor that influences vulnerability to other mental health difficulties, such as depression (Joormann & Gotlib, 2010; LeMoult & Gotlib, 2019).

Although researchers have not yet tested whether self-referential processing predicts symptoms of GAD during times of stress, there is reason to expect that negative self-referential processing contributes to the maintenance and exacerbation of GAD symptoms. For example, according to the self-efficacy conception of anxiety put forth by Bandura (1988), self-referential beliefs contribute to both anxious arousal and apprehensive thinking. Specifically, negative self-focused cognitions and perceived self-inefficacy are thought to decrease one's ability to cope with stressors, which in turn, increases worry and anxious arousal – two of the core features of generalized anxiety disorder (Bandura, 1988; Bandura, 2005). In addition, according to the Intolerance of Uncertainty model of GAD, uncertainty has substantial negative self-referent implications (Koerner & Dugas, 2006). For instance, increased intolerance of uncertainty is associated with negative self-appraisals such as the belief that being uncertain indicates that one is lacking in some way, as well as with reduced confidence in one's ability to cope with the future, and these negative self-appraisals are associated cross-sectionally with pathological worry and with analogue GAD status (Sexton & Dugas, 2009). Studies examining other internalising disorders also provide a degree of support for the association between self-referential processing and symptoms of GAD. To date, the majority of research on self-referential processing focuses on it as a risk factor for depression (see LeMoult & Gotlib, 2019, for a review). Researchers, for example, have documented that more negative and less positive self-referential processing predicts greater symptoms of depression (Connolly et al., 2016; Disner et al., 2017), particularly during times of

stress (LeMoult et al., 2017). Researchers have also posited that self-referential processing plays a role in anxiety disorders (Blair & Blair, 2012). Goldin et al. (2013), for example, found that socially anxious individuals held more negative and less positive self-referential views than their non-anxious counterparts. In addition, elevated GAD symptoms are associated with a construct related to negative self-referential biases (i.e. low self-concept clarity, a characteristic of an individual's self-concepts; Kusec et al., 2016). However, researchers have not yet examined whether individual differences in self-referential processing serve as a diathesis that predicts the severity and course of GAD symptoms or components during times of stress. This is surprising given that depression and GAD have the highest rates of comorbidity of all mood and anxiety disorders, have considerable symptom overlap, and are associated with similar underlying risk factors (e.g. Ruscio et al., 2011; Sunderland et al., 2010; Zbozinek et al., 2012). Despite reasons to expect that self-referential processing might contribute to symptoms of GAD, it is one of the only anxiety disorders for which prospective associations between self-referential processing and changes in symptoms has not been examined.

The primary aim of our research was to fill this gap in the literature by examining whether individual differences in self-referential processing were associated with aspects of GAD in response to stress. In order to investigate this association, we conducted two studies. In Study 1, we examined whether self-referential processing was associated with symptoms of GAD during a time of naturalistic stress. In Study 2, we extended our understanding of the association between self-referential processing and aspects of GAD by examining whether self-referential processing was associated with an acute laboratory-based stress response, as measured by changes in anxious affect and tension (two symptoms that typify GAD; Pluess et al., 2009).

Study 1

People entering university belong to the age range most at risk for developing a mental illness, particularly an anxiety disorder (Pearson et al., 2013). In fact, nearly one in six university students has been diagnosed with or treated for anxiety, and many more experience elevated symptoms (American College Health Association, 2015). Thus, it is critical to understand risk factors that lead to individual

differences in acute and sustained responses to the transition to university. Study 1 was designed to examine the prospective association between self-referential processing and symptoms of GAD during the initial and subsequent transition to students' first semester of university. The initial weeks of university can be an acutely stressful phase in one's life (American College Health Association, 2015). The initial weeks are often characterized by leaving existing support systems, entering a new social environment, and adapting to increased academic expectations and pressures. In the months that follow, there are substantial individual differences in the way students adjust to the ongoing stress of university (LeMoult et al., 2015).

In order to examine the prospective association between self-referential processing biases and symptoms of GAD during the transition to university, first-year university students were invited to participate in a laboratory session during the first four weeks of the semester. During this initial session (T1), participants completed the self-referential encoding task (SRET) and reported on their symptoms of GAD. We then followed participants across the semester in order to assess individual differences in longer-term changes in symptoms of GAD, and we asked them to report on their symptoms of GAD during their second (T2), third (T3), and fourth (T4) months of university. We expected that self-referential processing would predict individual differences in participants' symptoms during the initial transition to university (i.e. symptoms of GAD at T1) and the course of GAD symptoms over time (i.e. the trajectory of symptoms from T1 through T4) such that more negative and less positive self-referential processing at the start of the semester would predict greater symptoms of GAD at T1 and a more pernicious course of GAD symptoms over the semester.

Methods

Participants

Participants were 135 students (87% female) in their first semester of university. Participants were recruited through the Human Subject Pool run by the Department of Psychology and received partial course credit towards an eligible psychology course as remuneration. Any student who was in the first semester of their first year of university and fluent in English was eligible to participate. The mean age of participants was 18.28 years ($SD = 0.85$). Participants self-identified as Asian (57%), White (27%), Latinx (4%), or "other ethnicity" (12%).

Materials

Mood induction

Researchers have documented that cognitive biases remain latent until triggered by a negative mood state, and they posit that a negative mood state is required to activate negative cognitive biases and schemas among individuals at risk for psychopathology (Beck et al., 1985; Taylor & Ingram, 1999; Teasdale, 1988). Thus, consistent with past research utilising the SRET (e.g. Kircanski et al., 2013; LeMoult et al., 2017), participants completed a negative mood induction immediately before completing the SRET to assess participants' latent self-schemas. In order to induce a negative mood state, participants viewed a film clip from the movie *My Girl* (Zieff, 1991), which shows a young girl finding out about the death of her best friend. Participants were instructed to imagine themselves in the situation while watching the film clip and for two minutes following, as has been done in previous research (see LeMoult et al., 2017). To remain consistent with past research (LeMoult et al., 2017; Jopling et al., 2020), participants were asked to rate their sad mood before and after the mood induction on a 5-point scale ranging from 1 (*very slightly or not at all*) to 5 (*extremely*).

Self-referential encoding task

We measured self-referential processing using the SRET (Derry & Kuiper, 1981), a computer-based cognitive task presented with E-Prime 2.0 professional. The SRET consisted of 40 adjectives (20 positive and 20 negative; see online supplement) that have been used in numerous previous studies (e.g. Asarnow et al., 2014; Kircanski et al., 2013; LeMoult et al., 2017). The positive and negative word lists did not differ from one another in word length, familiarity, or level of arousal (ps > .05). Trials began with the phrase "Describes me?" presented for 500 ms, followed by a blank screen for 250 ms. Next, an adjective was presented, and participants indicated whether or not the adjective described them. All adjectives were presented in random order. At the conclusion of the encoding phase, participants completed a 3-minute distraction task: the WAIS-R digit-symbol task (Wechsler, 1981). Finally, participants were instructed to recall as many adjectives as they could from the SRET task,

regardless of whether they had endorsed the adjective as self-descriptive.

In this task, the self-referential endorsement ratings are crucial as they produce memory traces, the strength of which is assessed during the recall task (Derry & Kuiper, 1981). Given the interconnected nature of the endorsement and recall portions of the SRET, endorsement and recall data were both taken into account when scoring the task, as is consistent with past research (e.g. Auerbach et al., 2016; Jopling et al., 2020; Ramel et al., 2007). Specifically, we calculated two dependent variables for each participant based on their endorsement and recall of adjectives on the SRET. The first variable was the number of *positive* adjectives that they endorsed as self-descriptive, and also recalled (SRET-pos). The second variable was the number of *negative* adjectives that they endorsed as self-descriptive, and also recalled (SRET-neg). Some researchers have calculated an SRET ratio based on the proportion of negative words endorsed and recalled divided by the total number of positive and negative words endorsed. However, this variable is unable to disentangle the contribution of positive versus negative stimuli, which recent theoretical models and best-practice guidelines increasingly recommend (Goldin et al., 2013; Heimberg et al., 2010; LeMoult & Gotlib, 2019). Our use of the number of words recalled is also consistent with conclusions made by Dainer-Best et al. (2018) who found that the number of words recalled, not a ratio score, had the strongest association with symptoms of psychopathology.

Symptoms of anxiety

The Generalized Anxiety Disorder 7-item scale (GAD-7; Spitzer et al., 2006) was used to assess participants' symptoms of anxiety. The GAD-7 is a self-report measure that instructs participants to rate the frequency with which they experienced symptoms of anxiety over the past 2 weeks. The GAD-7 has shown good reliability and validity (Spitzer et al., 2006), and it showed good internal reliability with this sample, α = .872.

Covariates

Given evidence that both anxiety and the biased processing of emotional stimuli, such as self-referential encoding, are associated with depressive symptoms (LeMoult & Gotlib, 2019; Mineka et al., 1998) and female sex (Altemus et al., 2014; Stewart et al.,

1998), we included these variables as covariates in our model predicting symptoms of GAD in order to assess the unique contribution of self-referential processing after accounting for these variables. The severity of depressive symptoms was assessed with the Centre for Epidemiological Studies Depression Scales (CESD; Radloff, 1977). This 20-item self-report measure instructs participants to rate the frequency with which they experienced DSM symptoms of depression in the past week. The CESD has shown good reliability and validity (Radloff, 1977) and it showed good internal reliability with this sample, α = .883.

Procedure

This study received ethics approval from the Behavioural Research Ethics Board at the University of British Columbia. The study consisted of one laboratory session (T1) conducted during the first four weeks of the semester, followed by online surveys completed from home during the second (T2), third (T3), and fourth (T4) months of university. At the laboratory session (T1), participants first provided informed consent and then completed questionnaires and the negative mood induction, followed by the SRET. They also completed two additional cognitive tasks (the Dot Probe Task [MacLeod et al., 1986] and the Sternberg Task [Sternberg, 1969]), which were not part of these hypotheses and were not analyzed with these data. For the follow-up surveys (T2 – T4), participants were emailed a link to complete the GAD-7 and CESD. At the end of the study, participants were fully debriefed, were provided on-campus and community wellness resources, and were thanked for their time.

Analytic strategy

In order to examine the effects of self-referential processing on symptoms of GAD during the first semester of university, we used multilevel modeling to test whether SRET performance at baseline predicted symptoms of GAD, over and above baseline symptoms of depression and participants' sex, both of which were included as covariates. Multilevel modeling offers numerous advantages over traditional analytic approaches, including simultaneously modelling initial and subsequent GAD symptoms, estimating both within- and between-person effects, handling

varying time intervals between data collection points, and allowing for missing data. We used Hierarchical Linear Modeling (HLM) software version 6.08 (Raudenbush et al., 2004). Models were run using full maximum likelihood for estimating model fit and restricted maximum likelihood for estimating parameters. Experts recommend that a sample size of 50 at Level 2 is needed to achieve adequate power using HLM (Maas & Hox, 2005). Although our current sample size exceeded this guideline and evidence suggests that small sample sizes have little to no effect in biasing estimates of fixed effects in hierarchical models (Clarke & Wheaton, 2007), parameter estimates with robust standard errors are reported to minimize bias.

In order to determine the model that best captured the initial (GAD-7 symptoms at T1) and sustained response to the semester (GAD-7 symptom change modeled as days from T1 to T2, T3, and T4, respectively), we tested linear and quadratic models with no Level 2 predictors. The linear model provided the best fit to the data based on deviance statistics and lowest AIC (as recommended by Raudenbush & Bryk, 2002); thus the following Level 1 model was specified where π_{0j} reflects GAD-7 scores during the initial transition to university (i.e. at T1) and π_{1j} reflects the change in GAD-7 scores over time (i.e. the slope taking into account all four time points):

$$GAD - 7 = \pi_{0j} + \pi_{1j}(time) + e_{ij}$$

We then tested whether within-subject levels in GAD-7 scores were influenced by participants' SRET-neg and SRET-pos scores at baseline (covarying the effect of sex and CESD scores) at Level 2. The Level 2 models were as follows, where any given variable B reflects the association between that variable and levels of GAD-7 during the initial (T1) and sustained (slope of GAD-7 change over time) portion of students' first semester of university:

$$\pi_{0j} = B_{00} + B_{01}(sex) + B_{02}(CESD) + B_{03}(SRET - neg)$$
$$+ B_{04}(SRET - pos) + r_0$$
$$\pi_{1j} = B_{10} + B_{11}(sex) + B_{12}(CESD) + B_{13}(SRET - neg)$$
$$+ B_{14}(SRET - pos) + r_1$$

Results

Demographic and clinical characteristics

Demographic and clinical characteristics are presented in Table 1. All 135 participants who completed T1, completed at least one follow-up: 132 participants completed T2, T3, and T4, respectively. Participants who completed T2, T3, or T4 did not differ significantly from those who did not complete that time point based on sex, age, SRET-neg, SRET-pos, T1 CESD scores, or GAD-7 scores, $ps > .383$. Participants had a mean GAD-7 score at T1 of 7.01 (range 0-21; $SD = 4.53$), which is above the cut-off score of 5 that is indicative of mild anxiety yet below the cut-off score of 10 that is indicative of probable GAD (Spitzer et al., 2006). Participants had a mean CESD score at T1 of 17.97 (range 0-41; $SD = 8.87$), which is above the cut-off point of 16 that is typically used to indicate clinical depression (Weissman et al., 1977).

Mood induction

In order to ensure the effectiveness of the mood induction before the SRET task, a repeated-measures analysis of variance (ANOVA) was conducted on self-reported mood. As expected, this analysis yielded a significant main effect of time, $F(1,130) = 175.95$, $p < .001$, $\eta^2 = .575$. Participants endorsed more negative mood after watching the film clip ($M = 3.03$, $SD = 1.27$) than before ($M = 1.48$, $SD = .85$).

Table 1. Baseline demographic and clinical characteristics for the full sample of Study 1 participants (T1) and those who completed each of the three follow-ups (T2-T4).

	T1 $n = 135$	T2 $n = 132$	T3 $n = 132$	T4 $n = 132$
Age, $M(SD)$	18.28 (0.85)	18.29 (0.86)	18.27 (0.82)	18.29 (0.86)
Female, %	87%	87%	86%	86%
SRET-neg, M(Range, SD)	2.34 (0-8, 1.64)	2.31 (0-8, 1.64)	2.32 (0-8, 1.62)	2.37 (0-8, 1.64)
SRET-pos, M(Range, SD)	5.50 (0-11, 2.49)	5.52 (0-11, 2.50)	5.51 (0-11, 2.52)	5.48 (0-11, 2.51)
CESD T1, $M(SD)$	17.97 (8.87)	17.94 (8.89)	17.83 (8.71)	17.99 (8.95)
GAD-7	7.01 (4.53)	6.42 (5.04)	6.44 (5.22)	6.75 (5.33)

Correlations

Bivariate correlations between SRET-neg, SRET-pos, GAD-7 scores, and CESD scores are presented in Supplemental Table 1 (Table S1). Higher SRET-neg scores were associated with higher symptoms of GAD at all time points. In addition, higher SRET-pos scores were associated with lower symptoms of GAD at all time points with the exception of T2, when the association was at a trend level. Baseline symptoms of depression were associated with higher SRET-neg scores, lower SRET-pos scores, and greater GAD symptoms, supporting the importance of its inclusion as a covariate in the main analyses.

Association between SRET and symptoms of GAD

As expected, participants reported symptoms of GAD that were significantly greater than zero during the initial period of the transition to university (i.e. at T1), $B = 6.85$, $t(134) = 17.85$, $p < .001$, and remained stable over the course of the semester, $B = -0.005$, $t(134) = -0.76$, $p = .451$. Importantly, there were significant individual differences in levels of GAD at T1, $\chi^2(134) = 489.79$, $p < .001$, and in the degree of GAD change over time, $\chi^2(134) = 220.48$, $p < .001$. Analyses indicated that SRET-neg scores, $B = 0.37$, $t(130) = 1.99$, $p = .048$, pseudo-$R^2 = .033$[1], but not SRET-pos scores, $B = 0.09$, $t(130) = 0.54$, $p = .589$, pseudo-$R^2 = -.016$, were significantly associated with individual differences in levels of GAD at baseline. Specifically, more negative self-referential processing was associated with greater T1 symptoms of GAD. In contrast, SRET-pos scores, $B = -0.007$, $t(130) = -2.92$, $p = .004$, pseudo-$R^2 = .088$, but not SRET-neg scores, $B = 0.0003$, $t(130) = 0.07$, $p = .948$, pseudo-$R^2 = -.020$, significantly predicted change in the severity of GAD symptoms over the semester. Specifically, more positive self-referential processing was associated with a decline in anxiety symptoms over the semester. Consistent with this finding, results from a hierarchical linear regression showed that participants with higher SRET-pos scores reported significantly lower symptoms of GAD at T4, $\beta = -0.22$, $t(125) = -2.84$, $p = .005$, even after accounting for symptoms of GAD at baseline, SRET-neg scores, and the same covariates included in the HLM analyses (i.e. sex and CESD scores).[2] Additional analyses excluding these covariates are presented in the online supplement.

Study 2

Study 2 was designed to extend findings from Study 1 by investigating whether self-referential processing was associated with changes in anxious affect and muscle tension (anxiety-tension) in response to an acute laboratory stressor. While the transition to university is an excellent example of a naturalistic stressor, Study 2 enabled us to examine whether self-referential processing also predicts responses to a controlled laboratory stressor with distinct reactivity and recovery components. In Study 2, participants completed the SRET (Derry & Kuiper, 1981) and a threat-of-speech stressor, and they rated their levels of anxiety and tension before, during, and after the stressor. Given findings from Study 1, we predicted that negative self-referential processing would be associated with greater initial reactivity to the stressor. Given that we did not examine stress recovery in Study 1 and we are not aware of any previous research that has assessed the association between self-referential processing and stress recovery, we did not make any a priori expectations about this association.

Methods

Participants

An independent sample of undergraduate students in any year of study were recruited across the school year and participated in exchange for partial course credit. Participants were recruited through the Human Subject Pool run by the Department of Psychology and received partial course credit towards an eligible psychology course as remuneration. Any student who was fluent in English was eligible to participate. The mean age of participants was 20.60 years ($SD = 2.02$). Participants self-identified as Asian (57%), White (38%), Latinx and White (4%), and Asian and White (2%). Because a threat-of-speech manipulation was used to induce stress, it was critical to assess participants' belief that they would indeed give a speech. Thus, at the end of the study, participants reported whether they had believed they would have to give a speech, to which they replied 'yes' or 'no.' We decided a priori to conduct the final analyses on only those participants who believed the threat-of-speech manipulation. Of the original sample of 83 students, there was a subset of participants ($n = 27$) who did not believe the threat-of-speech manipulation, and as would be expected, participants who did not believe

the threat-of-speech manipulation exhibited an attenuated response to the stressor compared to participants who believed the threat-of-speech manipulation, $t(75)$ = 4.23, $p < .001$. Thus, consistent with past research (Bogdan & Pizzagalli, 2006), the final analyses were conducted on the 56 participants (86% female) who believed the threat-of-speech stress manipulation. Participants who did not believe the manipulation did not differ on age, proportion female, SRET-neg, SRET-pos, CESD scores, or GAD-7 scores, ps > .069.

Materials

Mood induction
Similar to Study 1, participants completed a negative mood induction immediately before completing the SRET. Participants watched a clip from the movie *Stepmom* (Columbus, 1998) in which children say goodbye to their dying mother and were asked to imagine themselves in the situation during the film clip and for two minutes following. Before and after the clip, participants reported their anxiety on a Likert scale ranging from 0 (*not at all*) to 100 (*extremely*). Although we assessed levels of sad mood in response to the negative mood induction in Study 1, we assessed anxious affect in response to the negative mood induction in Study 2. This was done to remain consistent with anxious affect ratings taken during the laboratory stressor in Study 2.

Self-referential encoding task
Participants completed the SRET (see Study 1 for details).

Stress induction
The stress induction was based on the "threat-of-speech" procedure developed by Kidorf & Lang, 1999 and used in previous research (e.g. Joormann et al., 2015). In order to induce mild stress, participants were told they would have to perform a 5-minute speech on their most undesirable quality in front of a committee of peers who would rate the quality of their speech and film it for later analysis. Participants prepared for this speech for 3 minutes (preparatory period). Subsequently, the experimenter told all participants that the speech could not be completed because the video equipment was broken. Participants then rested for 2 minutes (recovery period). Given that threat-of-speech and actual speech stress inductions produce comparable psychological and physiological stress responses (Waugh et al., 2010),

we chose to use a threat-of-speech stressor in order to minimize the duration of participants' stress.

To assess moment-to-moment changes in the intensity of GAD symptoms, participants were asked to report their level of anxious affect and their level of tension on a scale ranging from 0 ("Not at all") to 100 ("Extremely") three times during the stress induction: before the preparatory period (i.e. baseline), before being told they would not have to give the speech (i.e. stress), and after the recovery period (i.e. recovery). We elected to have participants rate their levels of anxiety and tension in order to capture the affective (i.e. anxiety) and physiological arousal (i.e. muscle tension) components of GAD. We focused on anxiety and tension as these are two core aspects of GAD. Indeed, researchers have documented that muscle tension is the most discriminative physiological symptom of GAD (Joormann & Stober, 1999; Pluess et al., 2009). Similar two-item affect and arousal measures have been used in past research assessing responses to a laboratory stressor in people with GAD (Kircanski et al., 2016). Levels of anxiety and tension were averaged in order to create a general *anxiety-tension* composite score at each time point (αs = .75-.89), and these scores were highly correlated with symptoms of GAD assessed with the GAD-7 (rs > .347, ps < .012).

Symptoms of anxiety and depression
Consistent with Study 1, symptoms of GAD were assessed with the GAD-7 (Spitzer et al., 2006) and symptoms of depression were assessed using the CESD (Radloff, 1977). For this sample, internal reliability was good for both the GAD-7, α = .849, and the CESD, α = .830.

Procedure

This study received ethics approval from the Behavioural Research Ethics Board at the University of British Columbia. Study 2 was completed in one laboratory session. After providing informed consent, participants completed questionnaires, and then they completed the mood induction followed by the SRET. Finally, participants completed the "threat-of-speech" stress induction, and levels of anxiety-tension were assessed three times during this period. At the end of the study, participants were fully debriefed using evidence-based debriefing procedures designed to alleviate participants' distress and address experiences of deception (Bargh & Chartrand, 2000; Kimmel et al., 2011). They were

also provided on-campus and community wellness resources.

Analytic strategy

In order to examine the effects of self-referential processing on changes in anxiety-tension during the laboratory stressor, we used multilevel modeling to test whether SRET performance at baseline predicted changes in anxiety-tension. Specifically, we tested whether within-subject changes in anxiety-tension over time (modeled as minutes from the first assessment) were influenced by participants' SRET-neg and SRET-pos scores at baseline; consistent with Study 1, baseline symptoms of depression and participants' sex were included as covariates, and analyses were conducted using HLM software version 6.08 (Raudenbush et al., 2004). Models were run using full maximum likelihood for estimating model fit and restricted maximum likelihood for estimating parameters; parameter estimates with robust standard errors are reported.

We tested linear, quadratic, and piecewise models with no Level 2 predictors in order to determine the model that best captured the change in anxiety-tension scores over time. Both quadratic and piecewise models fit the data significantly better than the linear model; however, the piecewise model was associated with the lowest AIC, fit the discontinuous nature of the reactivity versus recovery periods, was consistent with previous research examining distinct stress reactivity and recovery (e.g. Gotlib et al., 2015), and allowed us to parse apart predictors of reactivity from predictors of recovery, thereby offering advantages over the linear model and over area-under-the-curve (AUC) calculations. Thus, the following Level 1 model was specified:

$$Anxiety - tension = \pi_{0j} + \pi_{1j}(reactivity)$$
$$+ \pi_{2j}(recovery) + e_{ij}$$

In this model, π_{0j} reflects levels of anxiety-tension at baseline, π_{1j} reflects changes in anxiety-tension in response to the stressor (i.e. the slope from baseline to stress), and π_{1j} reflects changes in anxiety-tension during the recovery period (i.e. the slope from stress to recovery).

We then tested whether within-subject changes in anxiety-tension were influenced by participants' SRET-neg and SRET-pos scores at baseline (covarying the effect of sex and CESD scores) at Level 2. Thus, the Level 2 models were as follows where any given

variable B reflects the unique variance that variable predicts in mean anxiety-tension scores at baseline or over time, with random effects specified for stress reactivity and recovery:

$$Baseline levels of anxiety - tension: \pi_{0j} = B_{00} + b_{01}(sex)$$
$$+ B_{02}(CESD) + B_{03}(SRET - neg) + B_{04}(SRET - pos)$$
$$Anxiety - tension reactivity: \pi_{1j} = B_{10} + B_{11}(sex)$$
$$+ B_{12}(CESD) + B_{13}(SRET - neg) + B_{14}(SRET - pos) + r_1$$
$$Anxiety - tension recovery \; \pi_{2j} = B_{20} + B_{21}(sex)$$
$$+ B_{22}(CESD) + B_{23}(SRET - neg) + B_{24}(SRET - pos) + r_2$$

Results

Demographic and clinical characteristics

Demographic and clinical characteristics are presented in Table 2. The mean GAD-7 score of participants was 6.23 (range 0-21; $SD = 4.17$), which is above the cut-off score of 5 that is indicative of mild anxiety yet below the cut-off score of 10 that is indicative of probable GAD (Spitzer et al., 2006). The mean CESD score of participants at T1 was 19.30 (range 4-43; $SD = 7.62$), which is above the cut-off point of 16 that is typically used to indicate clinical depression (Weissman et al., 1977).

Manipulation check

In order to ensure the effectiveness of the mood induction before the SRET task, a repeated-measures ANOVA was conducted on self-reported anxiety. As expected, this analysis yielded a significant main effect of time, $F(1, 49) = 13.22$, $p = .001$, $\eta^2 = .212$. Participants endorsed more anxiety after watching the film clip ($M = 49.28$, $SD = 31.59$) than before ($M = 37.76$, $SD = 27.21$).

Correlations

Bivariate correlations between SRET-neg, SRET-pos, GAD-7 scores, and CESD scores are presented in

Table 2. Demographic and clinical characteristics for Study 2.

	Participant Characteristics ($n = 56$)
Age, $M(SD)$	20.56 (2.02)
Female, %	86%
SRET-neg, $M(Range, SD)$	1.86 (0-5, 1.35)
SRET-pos, $M(Range, SD)$	5.02 (0-12, 2.42)
CESD, $M(SD)$	19.30 (7.62)
GAD-7, $M(SD)$	6.23 (4.16)

Table 3. Final estimation of fixed effects with robust standard errors for predictors and covariates predicting GAD-7 scores in Study 1.

	Coeff (B)	SE	t	p
Intercept (GAD-7 scores at T1)				
Sex	-0.57	0.01	-0.56	.577
CESD	0.30	0.05	6.63	**<.001**
SRET-Neg	0.37	0.19	1.99	**.048**
SRET-Pos	0.09	0.17	0.54	.589
Time (change in GAD-7 scores over the course of the semester)				
Sex	-0.02	0.01	-1.06	.293
CESD	-0.003	0.001	-3.12	**.002**
SRET-Neg	0.0003	0.004	0.07	.948
SRET-Pos	-0.01	0.002	-2.92	**.004**

Note: Coeff = regression coefficient; SE = standard error.
Significant p-values are presented in bold.

Table S2 in the online supplement. As expected, higher SRET-neg scores were associated with significantly higher GAD-7 and CESD scores. Also as expected, SRET-pos scores were associated with significantly lower CESD scores. In contrast, the association between SRET-pos scores and GAD-7 scores was not significant, $p = .614$.

Association between SRET and anxiety-tension

Based on the baseline model (without any Level 2 predictors), participants demonstrated the expected response to the threat-of-speech stressor; anxiety-tension was significantly greater than zero at baseline, $B = 34.53$, $t(55) = 10.73$, $p < .001$, increased in response to the stressor, $B = 7.14$, $t(55) = 11.70$, $p < .001$, and declined during the recovery period, $B = -13.20$, $t(55) = -12.46$, $p < .001$.

Neither SRET-neg nor SRET-pos scores predicted anxiety-tension at baseline, $ps > .191$. Consistent

Table 4. Final estimation of fixed effects with robust standard errors for predictors and covariates predicting anxious-tension in Study 2.

	Coeff (B)	SE	t	p
Intercept (anxiety-tension at baseline)				
Sex	10.30	7.47	1.38	.175
CESD	1.12	0.53	2.13	**.039**
SRET-Neg	-3.69	2.77	-1.33	.191
SRET-Pos	-0.42	1.36	-0.31	.759
Reactivity (changes in anxiety-tension in response to the stressor)				
Sex	1.39	1.24	1.12	.268
CESD	-0.04	0.08	-0.50	.621
SRET-Neg	1.14	0.56	2.06	**.045**
SRET-Pos	-0.005	0.25	-0.02	.986
Recovery (change in anxiety-tension during the recovery period)				
Sex	-3.83	2.22	-1.72	.091
CESD	-0.17	0.12	-1.39	.171
SRET-Neg	-0.56	1.01	-0.56	.580
SRET-Pos	-0.06	0.38	-0.17	.867

Note: Coeff = regression coefficient; SE = standard error.
Significant p-values are presented in bold.

with our hypothesis, SRET-neg scores, $B = 1.14$, $t(51) = 2.06$, $p = .045$, pseudo-$R^2 = .007$, but not SRET-pos scores, $B = -0.01$, $t(51) = -0.02$, $p = .986$, pseudo-$R^2 = .013$, predicted individual differences in participants' reactivity to the stressor. Specifically, higher SRET-neg scores were associated with greater reactivity to stress.[3] Neither SRET-neg nor SRET-pos significantly predicted recovery from the stressor, $ps > .580$. Additional analyses excluding sex and CESD scores at Level 2 are presented in the online supplement.

General discussion

In the current studies, we examined the association of self-referential processing biases with symptoms of GAD in the context of the transition to university, a time of naturalistic stress (American College Health Association, 2015; Study 1) and with levels of anxious affect and muscle tension in response to an acute laboratory-based stressor (Study 2). Overall, we found that more negative self-referential processing was associated with greater initial anxiety as indexed by greater symptoms of GAD when students first started university and increased anxiety-tension reactivity in response to the acute laboratory stressor. In contrast, positive self-referential processing appeared to serve as a longer-term protective factor such that greater positive self-referential processing was associated with a decline in GAD symptoms across students' first semester of university.

The current research provides the first test of the association between self-referential processing and individual differences in change in symptoms of GAD. Our findings document important valence-specific effects. Specifically, we found that negative and positive self-referential processing played distinct roles in the initial versus sustained responses to the transition to university such that negative self-referential processing was associated with higher levels of GAD-7 scores during students' first month of university, whereas positive self-referential processing facilitated more adaptive responses to the first semester of university. In contrast, contrary to our initial expectations, negative self-referential processing was not associated with changes in GAD symptoms over the semester. Although this study is the first to examine the association between self-referential processing and the course of GAD symptoms, Disner and colleagues documented that negative self-referential processing did not predict the trajectory of depressive symptoms (Disner et al., 2017). In contrast, LeMoult et al. (2017)

found that negatively biased self-referential processing was associated with the recurrence of depressive episodes. However, LeMoult and colleagues used a composite measure of self-referential processing that included both negative and positive self-referential processing but did not differentiate between them. Taken together, there is evidence that it is important to conceptualise negative and positive self-referential processing as two independent and dissociable constructs. Indeed, we found that positive and negative self-referential processing were not significantly correlated with each other in either Study 1 or Study 2 (see Table S1 and S2 in the online supplement). As such, positive and negative self-referential processes may be largely independent constructs with distinct consequences and, as such, they may also have distinct causes. This proposition is consistent with evidence found in past research that negative and positive aspects of the self are distinct and separable (De Pisapia et al., 2019; Ke et al., 2018). Indeed, distinct neural regions are involved in processing negative and positive self-referential material, with the medial prefrontal cortex (mPFC) demonstrating preferential processing and encoding of negatively charged attributes of the self (De Pisapia et al., 2019). This formulation is also consistent with theoretical models of positive and negative affect more broadly (Tellegen et al., 1999) and with the Research Domain Criteria (RDoC) initiative, which proposes that positive and negative valence are two separate and distinct domains (Insel et al., 2010; Kozak & Cuthbert, 2016).

Importantly, SRET-pos scores were associated with changes in symptoms of GAD in Study 1 but not with in anxiety-tension in Study 2. Study 1 examined changes in symptoms of GAD over months of a sustained naturalistic stressor. Consistent with past research showing that symptoms remain elevated throughout students' first semester of university (LeMoult et al., 2015), participants in the current study reported symptoms of GAD above the cut-off of 5 at each time-point (Spitzer et al., 2006). Importantly, there were substantial individual differences in the chronicity of symptoms over time, and findings from Study 1 document that positively biased self-referential processing predicted individual differences in the chronicity of symptoms. In contrast, in Study 2 we assessed recovery from an acute laboratory stressor based on changes in anxiety-tension (a composite score designed to capture the affective and physiological components of GAD), and on average, we found a significant decline in anxiety-tension during the

recovery period. Thus, although positive self-referential processing may not influence recovery from acute stress, findings suggest that it is important during longer-term periods of transition, aiding in resilience and the ability to cope with sustained stressors. This supports the growing literature documenting the psychological benefits of holding a positive cognitive bias. Kleim et al. (2014), for example, found that positive interpretation biases were associated with higher trait resilience and a lower risk of symptoms of psychopathology over time. However, it is also important to note that in Study 2, although we found a significant effect for negative but not positive self-referential processing, results from a likelihood ratio test indicated that they did not significantly differ from one another, $\chi 2 = 5.20$, $p > .50$.

It is also interesting to consider why SRET-neg scores were associated with baseline levels of GAD symptoms in Study 1, but SRET-neg scores were not associated with baseline levels of anxiety-tension in Study 2. There were several important methodological differences between Study 1 and Study 2 that may account for this divergent pattern of findings. One possibility is that Study 1 and Study 2 were conducted in slightly different populations: Study 1 included only first-year undergraduate students, whereas Study 2 included undergraduate students across all years of study. It is also important to take into account that although we assessed components of GAD in Study 2, we assessed only state levels of anxiety and tension, which is distinct from assessing GAD symptoms more comprehensively.

There are several limitations of the current studies. First, in Study 1, we examined participants across the first four months of university. A longer follow-up period (e.g. the entire first year of university), may have afforded a more complete examination of the transition to university. Second, in Study 1 we did not assess CESD scores at all time points. Although we controlled for Time 1 CESD scores when predicting both Time 1 GAD symptoms and the change in GAD symptoms over time, it is possible that some participants may have experienced fluctuating depressive symptoms over time. Thus, we are unable to fully disentangle the overlap of depression and GAD symptoms. Third, in both studies, we focused on university students specifically, and the majority of participants were female. We chose this population given the prevalence of anxiety symptoms in university students (American College Health Association, 2015), the benefits of considering symptoms along a

continuum rather than dichotomy (Beevers et al., 2019; Widiger & Samuel, 2005), and the advantages offered by the naturalistic stressor of the transition to university. Nevertheless, we do not know whether our findings would generalise to people diagnosed with GAD. Thus, future research should seek to replicate this work in larger samples of general community and clinical populations. Further, in Study 2, we used a threat-of-speech stressor, and a substantial portion of participants did not believe the manipulation. Although we conducted analyses on only those participants who did believe the manipulation, this study should be replicated for ecological validity. It is also important to note that we are unable to determine whether general psychopathology or other anxiety/stress-related disorders (e.g. social anxiety disorder, posttraumatic stress disorder) influence the association of self-referential processing with symptoms of GAD. Psychiatric comorbidly is insufficiently accounted for in research on self-referential processing. We believe that the current study takes a first step toward accounting for comorbid levels of depression, and we hope that researchers will build on our findings by accounting for additional psychiatric comorbidity in future research. Finally, while the association between negative self-referential processing and stress reactivity was statistically significant in Study 2, effect size calculations suggested that this effect is quite small. Conclusions should thus be interpreted in light of this fact.

Despite these limitations, results of these studies have important implications. First, the findings reported here suggest that it may be valuable to consider self-referential processing when investigating symptoms of GAD. Given that this is the first study to examine these associations, there are many exciting avenues for future research, including determining whether self-referential processing is associated with a diagnosis of GAD. If replicated in clinical samples of people with GAD, our findings have the potential to inform theoretical models of GAD (see Behar et al., 2009 and Hirsch & Mathews, 2012), which to date, have not taken self-referential processing into account. For instance, the Intolerance of Uncertainty Model (IUM; Dugas et al., 1998, 2004) as well as the Emotion Dysregulation Model (EDM; Mennin et al., 2004) of GAD incorporate views about the self and one's own characteristics and abilities to cope with and regulate experiences inherent to GAD, such as chronic worry and emotional hyperarousal. By incorporating self-referential processing, these models could more formally acknowledge the role of views about the self as a pre-existing diathesis that influences components of GAD across time and in response to stress. By advancing our understanding of the cognitive processes that exacerbate versus attenuate symptoms of GAD in times of stress and transition, future research is better positioned to develop more effective preventative strategies for university students.

Notes

1. The presented pseudo-R^2 values should be interpreted with caution. As noted by Snijders and Bosker (2011), MLM is not well suited to traditional computations of effect size or proportion of variance explained as calculations of the proportion of variance are typically lower-level estimates of the true amount of variance explained by the predictor variable of interest. Further, there are instances in which the addition of a predictor variable can decrease the proportion of variance explained by the model which can result in a negative pseudo-R^2 value, as we observed for several analyses in the present study (see Hox, 2002).
2. [i] We also conducted exploratory analyses to examine whether SRET scores predicted levels of depression at baseline (controlling for baseline symptoms of GAD and sex). Although GAD-7 scores were significantly associated with levels of depression, β = 0.595, t(134) = 8.47, p < .001, neither SRET-neg, nor SRET-pos, βs < .133, ps > .076, were significantly associated with symptoms of depression at baseline.
3. This finding remained significant when baseline GAD-7 scores were included as a covariate.

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