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Changing the Conceptualization of Stress in Social Anxiety Disorder: Affective and Physiological Consequences

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Abstract
Social anxiety disorder (SAD) is a pervasive problem associated with debilitating impairments in social settings. This research explored the affective and physiological reactions to social evaluation and examined the efficacy of an arousal reappraisal intervention in altering cardiovascular reactivity and affective responses. Across two studies, socially anxious participants exhibited a disjunction between subjective ratings and physiological responses. Whereas anxious individuals reported more anxiety and negative affect during a stressful public speaking task relative to nonanxious controls, no differences emerged in physiological reactivity as a function of anxiety. In the second experiment socially anxious and nonanxious participants instructed to reframe stress arousal as a positive coping tool exhibited reduced attentional bias and improvements in physiological functioning: decreased vasoconstriction and increased cardiac efficiency. This research suggests that outcomes in SAD may be improved by reappraising stress arousal.

Keywords
social anxiety, emotion regulation, reappraisal, psychophysiology, replication

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Social anxiety disorder (SAD) is among the most prevalent of all mental disorders, with an overall lifetime rate of 12.2% (Kessler et al., 2005). People with SAD perceive that they are being negatively evaluated by others, and this often leads to debilitating impairments during social situations where there exists some element of evaluation (e.g., dates, interviews, talking to strangers; Stein & Kean, 2000; Stein, Torgrud, & Walker, 2000). The current research explored the effects of negative social evaluation in a sample of socially anxious individuals with two goals in mind. The first goal was to assess the subjective, physiological, and attentional consequences stemming from negative evaluation in socially anxious and nonanxious participants to compare possible differences in affective responding. The second goal was to examine the efficacy of a reappraisal intervention that was effective previously in non–socially anxious samples to determine if socially anxious individuals also could benefit from reappraising stress arousal (Jamieson, Mendes, Blackstock, & Schmader, 2010; Jamieson, Mendes, & Nock, 2013; Jamieson, Nock, & Mendes, 2012).

Although stressful evaluative situations commonly elicit feelings of anxiety and negative affect (e.g., Daly, Vangelisti, & Lawrence, 1989), these outcomes are exacerbated in SAD (e.g., Etkin & Wager, 2007). It is interesting, however, that research on acute physiological responses to evaluation has yielded inconsistent findings. Some research suggests that socially anxious and nonanxious individuals exhibit similar physiological responses to evaluative threat (e.g., Mauss, Wilhelm, & Gross, 2004), whereas others indicate that SAD is associated with maladaptive patterns of responding in such situations (e.g., increased blood pressure; Turner, Beidel, & Larkin, 1986).

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The discrepancy in the empirical data may hinder the development of process-focused and pharmacological treatment options because it is unclear if interventions should target actual physiological arousal or simply perceived arousal.

Stress Appraisals and Physiological Responses

Cognitive appraisals play an integral role in the generation and regulation of affective states (e.g., Barrett, 2006a; Gross, 2003). Commonly held beliefs imply that the heightened physiological arousal that accompanies stressful situations accumulates and results in poor health (Geronimus, Hicken, Keene, & Bound, 2006; Matthews et al., 2004; McEwen, 2006). However, not all increases in physiological arousal are necessarily deleterious for performance and health. In addition to associations with negative outcomes, increases in sympathetic nervous system (SNS) activation during active tasks have been linked to benign, approach-related responses (Dienstbier, 1989). Whether SNS activation is benign or not may depend on how the individual appraises the demands of the stressful situation and his or her ability to cope.

The biopsychosocial model of challenge and threat provides a theory of how appraisals of situational demands interact with appraisals of available coping resources to determine stress responses (see Blascovich & Mendes, 2010, for a review). Both *challenge* and *threat* states are experienced during situations of acute stress but differ in antecedent processes and downstream responses. Individuals experience challenge when appraisals of personal resources exceed situational demands. Alternatively, threat manifests when perceptions of demands exceed resources. Although both states are accompanied by increases in SNS activation, challenge is characterized by improved cardiac efficiency and dilation of the peripheral vasculature, whereas threat decreases cardiac efficiency and constricts the vasculature in anticipation of damage or defeat. Thus, modifying appraisals may promote adaptive patterns of responding.

Arousal Reappraisal

Changing cognitive appraisals, or reappraising, is a centerpiece of cognitive behavioral therapy (CBT). Reappraisal, as characterized in the clinical literature, typically either decreases arousal (e.g., mindfulness meditation; Cincotta, Gehrman, Gooneratne, & Baime, 2011) or teaches individuals to accept high arousal (e.g., interoceptive exposure; Levitt, Brown, Orsillo, & Barlow, 2004), but the context in which the arousal is experienced is critical in determining whether arousal is benign or malignant. Social evaluative situations typically are not passive and require instrumental cognitive responses such as giving a speech, taking a test, or negotiating. In situations like these, individuals must marshal biological and cognitive resources to actively cope with the tasks. Although some CBT methods include information about the adaptive functions of biological responses (e.g., Barlow, 2007), the clinical literature has yet to test approaches that seek to maintain adaptive levels of SNS activation during acute stress.

Toward this end, the current research examined the potential benefits of reappraising stress arousal in SAD. The arousal reappraisal perspective seeks to change the conceptualization of stress by informing individuals that arousal can be thought of as a resource that can *enhance* performance (cf. Barrett, 2006b; Lindquist & Barrett, 2008; Lindquist, Wager, Kober, Bliss-Moreau, & Barrett, 2011). That is, it seeks to promote approach-oriented patterns of responding while maintaining stress arousal necessary for optimal performance. In previous research, participants who reframed arousal as an adaptive coping strategy during acute stress exhibited improved physiological and cognitive outcomes (Jamieson et al., 2010; Jamieson et al., 2012). Reframing stress arousal is hypothesized to increase appraisals of coping resources, which are predicted to attenuate threat responses and promote a more adaptive profile of reactivity in socially anxious individuals. However, before testing the impact of arousal reappraisal, we first sought to better understand the physiological and affective reactivity that accompanies social evaluative threat in individuals with SAD.

Experiment 1

Individuals with SAD exhibit heightened self-reported negative affect (Etkin & Wager, 2007; Goldin, Manber, Hakimi, Canli, & Gross, 2009; Watson, Clark, & Carey, 1988) and stronger attentional capture for threat cues in the face of negative evaluation compared to less anxious individuals (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). However, the link between anxiety and physiological responses to evaluative situations is not as straightforward. Whereas many studies have observed differences in physiological reactivity between anxious and nonanxious individuals (e.g., Condren, O'Neill, Ryan, Barrett, & Thakore, 2002; Davidson, Marshall, Tomarken, & Henriques, 2000; McTeague et al., 2009; Roelofs et al., 2009; Stein, Asmundson, & Chartier, 1994; Turner et al., 1986), others have found no effects (e.g., Edelmann & Baker, 2002; Grossman, Wilhelm, Kawachi, & Sparrow, 2001; Krämer et al., 2012; Schmitz, Krämer, Tuschen-Caffier, Heinrichs, & Blechert, 2011).

Methodological differences across studies may contribute to these inconsistencies. For instance, a standard

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cross-sectional design exposes a group of anxious and nonanxious individuals to a stressful task—often the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993)—and examines the group differences in reactivity. This approach may overstate the effect of anxiety on physiological reactions if controls are selected only from the "nonanxious tail" of the anxiety spectrum. Consistent with this notion, in studies that have examined the relationship between social anxiety and physiological responses to evaluation in subclinical samples, most have observed no differences as a function of anxiety (Baggett, Saab, & Carver, 1996; Eckman & Shean, 1997; Mauss, Wilhelm, & Gross, 2003, 2004) versus significant relationships (Shimizu, Seery, Weisbuch, & Lupien, 2011). On the flip side, studying group differences using only evaluative tasks (i.e., without no-evaluation control conditions) misses information gleaned from a group's baseline. Experiment 1 sought to address some of these factors by crossing a stress induction (the TSST with and without evaluation) with anxiety level (clinically anxious vs. subclinical controls), with the nonanxious participants falling anywhere below the threshold for clinical anxiety. Then we examined physiological reactivity, as well as raw baseline scores, during stress anticipation, throughout the TSST, and during a recovery period.

Participants assigned to receive negative evaluation during the TSST were expected to display a physiological threat response and exhibit vigilance for threat cues relative to those assigned to the no evaluation condition. We were agnostic about the effects of social anxiety on physiological responses given the inconsistencies in the literature, though we did expect the socially anxious participants to exhibit more attentional bias than less anxious individuals. Finally, we tested the interaction between social anxiety and evaluation to examine whether potential differences between anxious and nonanxious participants were greater in the negative evaluation versus no evaluation condition.

Method

Participants. Participants were 72 adults (42 women, 30 men; *M* age = 26.63) recruited from the community via flyers, Harvard University's study pool, and postings on Craigslist.org (Boston, MA location). Participants were excluded for hypertension, the presence of a pacemaker, cardiac medications, body mass index (BMI) scores greater than 33, and pregnancy. Participants were also asked if they were taking any prescription medications at the time of the study. Of participants, 43% reported taking at least one medication (18 anxious, 13 nonanxious). In all, 5 participants (3 socially anxious, 2 nonanxious) asked to stop participation prior to study completion and were excluded from analyses. Sessions were completed in the afternoon/evening with start times between 12 p.m. and 6 p.m. Participants were compensated with $25.

The socially anxious group (n = 33) consisted of individuals meeting the diagnostic criteria for SAD as determined by the Mini International Neuropsychiatric Interview (MINI; Sheehan et al., 1998). Nonanxious controls (n = 34) also completed the MINI and did not meet the criteria for any of the anxiety or mood disorders assessed. There were no differences between groups on age, sex, or race/ethnicity.

Procedure. Upon arrival, participants provided consent for the physiological portion of the experiment and completed an initial set of questionnaires (see the Questionnaires section). The experimenter then affixed sensors, and participants relaxed for a 5-min baseline recording. After baseline, participants heard a description of the TSST, provided a verbal consent, and were assigned to one of two evaluation conditions: social evaluation or no evaluation. Those subject to social evaluation delivered a 5-min videotaped speech about their strengths and weaknesses to two interviewers who provided negative nonverbal feedback throughout. No-evaluation controls delivered the same speech but did so alone and believed nobody could see or hear them. Prior to speaking, participants were given 3 min to prepare. An impromptu 5-min mental arithmetic task (counting backward in steps of 7 from 996) followed the speech. In the evaluation condition, the interviewers again provided negative feedback. Controls completed the task alone.

Participants then completed post-TSST questionnaires and performed an emotional Stroop task (Williams, Mathews, & MacLeod, 1996) to measure attentional bias. Participants were asked to name the font color (red, green, or blue) of words as quickly and accurately as possible. Words were printed in two lists of 100 (one list comprised threat words and the other list comprised neutral words) and were presented in four columns of 25 words each. Participants were instructed to read down columns from left to right. Order was counterbalanced, and an experimenter unaware of condition assignment recorded errors and how long it took participants to read each list. Interference scores were computed by subtracting the time it took participants to read the neutral list from their time on the negative list.

Physiological measures. The following measures were collected at baseline, throughout the TSST (preparation period, speech, and mental arithmetic), and during a 3-min recovery period immediately following the TSST: electrocardiography (ECG), impedance cardiography (ICG), and blood pressure. Signals were integrated with Biopac MP100 hardware. ECG and ICG signals were scored offline by trained personnel. Signals were visually

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examined, and the ensembled averages were analyzed using Mindware software. Reactivity scores were computed by subtracting scores taken during the final minute of baseline from those collected during the first minute of the preparation, speech, and math periods. Analyses focused on pre-ejection period (PEP)—a measure of sympathetic activation—and two measures that allow distinction between challenge and threat: cardiac output (CO) and total peripheral resistance (TPR).

PEP indexes the contractile force of the heart by measuring the time from the initiation of left ventricle contraction to aortic valve opening. Greater sympathetic activation is indicated by shorter PEP intervals. CO is the amount of blood ejected from the heart during 1 min and is calculated by estimating stroke volume (the amount of blood ejected per beat) and multiplying by heart rate. Increases in CO indicate improved cardiac efficiency and typically are observed in challenge (Mendes, Blascovich, Lickel, & Hunter, 2002). TPR is a measure of overall vasoconstriction/vasodilation. When threatened, the vasculature constricts so as to limit blood flow to the periphery, producing high TPR scores. TPR was calculated with the following formula: (mean arterial pressure / CO) × 80.

Questionnaires

Social anxiety. The Interaction Anxiousness Scale (IAS; Leary & Kowalski, 1993) and the Beck Anxiety Inventory (BAI; Steer & Beck, 1997) were administered prior to baseline.

Stress appraisals. Participants completed a resource/demand appraisal questionnaire (Mendes, Gray, Mendoza-Denton, Major, & Epel, 2007) pre- and post-TSST. Composites of demands (Cronbach's α = .79) and resources (Cronbach's α = .74) were computed across time point.

Data analytic plan. Unless otherwise noted, data were analyzed in 2 (Anxiety: socially anxious vs. nonanxious) × 2 (Evaluation: social evaluation vs. no evaluation) between-subjects ANOVAs. A total of 14 socially anxious participants (42.42% of the anxious group) reported a history of depression. Research suggests that comorbid depression moderates the association between social anxiety and physiology (Yoon & Joormann, 2012). We included self-reported depression history (scored as a bivariate variable), medication status (scored as a bivariate variable), and the date since females' previous menstrual cycle as covariates. However, none of these covariates affected the pattern of results, and they are thus not reported.

One participant did not complete all IAS items and was not included in that analysis. Due to equipment problems, the physiological data from two anxious participants assigned to the no evaluation condition could not be analyzed.

Results

Questionnaires

Social anxiety. As expected, analysis of the BAI indicated that socially anxious participants reported higher levels of anxiety (M = 1.03, SD = 0.67) than nonanxious controls (M = 0.53, SD = 0.58), $F(1, 63) = 10.10$, p = .002, d = 0.80. Likewise, socially anxious participants reported more anxiety (M = 3.97, SD = 0.51) than controls (M = 2.30, SD = 0.53) on the IAS, $F(1, 62) = 161.84$, $p < .001$, d = 3.23.

Stress appraisals. Anxious participants indicated they possessed fewer coping resources (M = 3.88, SD = 0.92) compared to nonanxious participants (M = 4.70, SD = 0.75), $F(1, 63) = 16.90$, $p < .001$, d = 1.03. Analysis of resources also produced a marginal effect for evaluation, $F(1, 63) = 3.31$, p = .073, d = 0.46. Participants subject to social evaluation reported marginally fewer resources (M = 4.12, SD = 1.03) compared to those not evaluated (M = 4.47, SD = 0.79).

Analysis of demand appraisals produced main effects for anxiety, $F(1, 63) = 41.06$, $p < .001$, d = 1.61, and evaluation, $F(1, 63) = 10.60$, p = .002, d = 0.82, as well as an Anxiety × Evaluation interaction, $F(1, 63) = 4.10$, p = .047, d = 0.51. Contrasts indicate that anxious participants experienced the task as more demanding (M = 3.87, SD = 0.76) than nonanxious participants in the no evaluation condition (M = 2.93, SD = 1.08), $F(1, 63) = 9.40$, p = .003, d = 0.77, and this difference was stronger in the evaluation condition ($M_{anxious}$ = 5.00, SD = 0.89; $M_{nonanxious}$ = 3.87, SD = 0.73), $F(1, 63) = 34.85$, $p < .001$, d = 1.49.

Physiological measures. We first analyzed raw physiological signals (PEP, CO, and TPR) at baseline with BMI included as a covariate to examine whether anxious and nonanxious participants exhibited baseline differences that might mask reactivity effects. Analysis of PEP, CO, and TPR yielded only one effect. Socially anxious participants exhibited less SNS activation (higher PEP scores) at baseline (M = 115.51 ms, SD = 11.61 ms) relative to less anxious participants (M = 111.17 ms, SD = 10.72 ms), $F(1, 61) = 4.15$, p = .046, d = 0.52. However, this effect runs counter to the expected direction.

Physiological reactivity data were then analyzed in 2 (Anxiety) × 2 (Evaluation) × 4 (Time: preparation period vs. speech vs. mental arithmetic vs. recovery) mixed ANCOVAs with time as a within-subjects factor and BMI included as a covariate. See Table 1 for means and standard deviations.

Analysis of PEP reactivity produced main effects for time, $F(1, 61) = 7.33$, p = .009, d = 0.69, and evaluation, $F(1, 61) = 26.32$, $p < .001$, d = 1.31. Sympathetic reactivity was higher during the more metabolically demanding tasks (speech and mental math) versus the less active

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Table 1. Physiological Reactivity as a Function of Evaluation Condition and Anxiety Level

	Preparation period		Speech delivery		Mental arithmetic		Recovery	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
			Pre-ejection period (ms)					
No evaluation, nonanxious	–1.76	3.93	–3.74	7.04	0.29	5.72	0.88	5.37
No evaluation, socially anxious	–2.00	4.93	–3.33	6.73	–1.33	8.55	–1.00	7.12
Negative evaluation, nonanxious	–5.12	7.91	–13.54	12.20	–12.65	11.20	–3.82	8.20
Negative evaluation, socially anxious	–10.01	8.15	–15.00	8.94	–12.57	9.13	–6.56	5.69
			Cardiac output (liters/minute)					
No evaluation, nonanxious	0.15	0.87	0.48	1.09	0.13	1.08	–0.22	0.78
No evaluation, socially anxious	0.05	0.46	0.45	0.83	0.16	0.69	0.05	0.75
Negative evaluation, nonanxious	–0.04	0.72	0.39	0.90	0.44	1.25	–0.36	1.17
Negative evaluation, socially anxious	0.12	1.01	0.45	0.90	0.46	1.75	0.01	0.51
			Total peripheral resistance (dyne-sec × cm^{-5})					
No evaluation, nonanxious	18.66	85.68	51.33	155.27	58.32	105.78	40.28	106.55
No evaluation, socially anxious	8.19	95.64	14.43	67.58	30.29	105.16	34.70	114.80
Negative evaluation, nonanxious	100.33	120.29	216.84	152.46	216.84	177.93	178.76	202.48
Negative evaluation, socially anxious	122.63	123.89	189.37	160.65	189.37	160.80	159.84	172.96

recovery period, $F(1, 61) = 7.98$, $p = .006$, $d = 0.72$, and participants subject to evaluation exhibited more sympathetic arousal compared to those who were not evaluated.

We then examined the impact of anxiety and evaluation on CO. This analysis produced only a main effect for time, $F(1, 61) = 5.33$, $p = .024$, $d = 0.59$. CO reactivity was greater during the speech and math tasks versus recovery, $F(1, 61) = 4.75$, $p = .033$, $d = 0.56$. Finally, analysis of TPR produced the predicted main effect for evaluation, $F(1, 61) = 26.31$, $p < .001$, $d = 1.31$. Replicating previous work (e.g., Kassam, Koslov, & Mendes, 2009), participants subject to social evaluation exhibited greater vasoconstriction relative to nonevaluated participants.

The data indicate that, in general, social evaluation (vs. no evaluation) produced a threat pattern of responding: sympathetic activation, little or no change in CO, and increased vascular resistance. These effects not only were observed when the evaluators were present, but also emerged during anticipation of speaking and lasted into recovery. It is interesting that no differences in reactivity emerged as a function of anxiety. Consistent with this notion, neither IAS nor BAI reports were correlated with any of the physiological reactivity measures, *p*s > .21.

Attentional bias. The emotional Stoop assessed participants' vigilance for threat cues, and consistent with predictions, we observed the two main effects (see Fig. 1). Participants subject to social evaluation were more vigilant for threat cues compared to those in the no-evaluation condition, $F(1, 63) = 4.37$, $p = .040$, $d = 0.53$, and socially anxious participants were marginally more vigilant than non–socially anxious participants, $F(1, 63) = 3.69$, $p = .059$, $d = 0.48$.

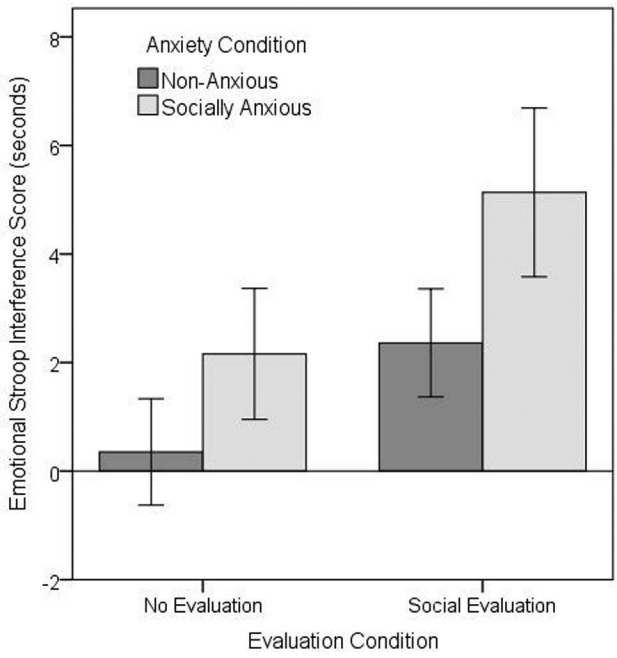

Fig. 1. Attentional bias as a function of anxiety level and evaluation condition. Error bars represent +/– standard error of the mean.

These attention effects cannot be attributed to a speed-accuracy trade-off as neither anxiety nor evaluation affected the number of errors participants made on the neutral (overall $M = 0.76$, $SD = 1.32$) or emotionally

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negative word lists (overall $M = 1.04$, $SD = 1.15$), $ps > .20$. Further examination of the relationship between anxiety and attentional bias revealed a correlation between IAS reports and attention. Participants reporting more social anxiety exhibited greater threat-related attentional bias, $\beta = .276$, $p = .035$.

Discussion

Consistent with published research, social evaluation produced a threat pattern of physiological responding (e.g., Blascovich, Mendes, Hunter, & Salomon, 1999). However, we observed no differences in autonomic reactivity between the SAD group and less anxious controls. Moreover, individual differences in anxiety reports were not associated with physiological responses to negative evaluation. Socially anxious individuals' cardiovascular responses to social evaluation were similar to those of nonanxious individuals. The lack of statistically significant differences as a function of anxiety, however, does not suggest that socially anxious participants responded adaptively to evaluative threat. Rather, all participants displayed a threat pattern of reactivity.

In contrast, anxiety and evaluation conditions significantly affected attentional bias and self-report measures. Socially anxious participants exhibited more attentional bias than did nonanxious participants. Likewise, participants assigned to receive social evaluation were more vigilant for emotionally negative information compared to those not evaluated. This pattern is consistent with meta-analytic data demonstrating that anxiety is associated with biased attention for threat cues (Bar-Haim et al., 2007). On the other hand, some previous work suggests that social anxiety is associated with less attention to threat cues (Amir et al., 1996). However, in that research, anxious participants completed the attention measure prior to a stressful public speaking task during an anticipatory period, whereas here it was completed following the stress task. Preparation takes effort that may suppress attentional bias given that increased cognitive effort can tax resources (Beilock, Rydell, & McConnell, 2007). However, in the current research participants had no need to use cognitive resources to plan the speech because the stress task was over.

Evaluation and anxiety also altered appraisals. Evaluated participants reported an increase in situational demands and a decrease in their available resources to cope with the stressor, with socially anxious participants exhibiting an exacerbated pattern (lower resource appraisals, higher demand appraisals) compared to nonanxious individuals.

Experiment 1 indicates that socially anxious individuals self-reported more anxiety and behaviorally exhibited greater vigilance for threat cues compared to less anxious individuals, but the anxious and nonanxious groups' physiological reactivity was not significantly different. It is important to note that any conclusion regarding the lack of physiological reactivity effects is preliminary because it is based on interpreting null results on a relatively small sample. However, these data are informative because they suggest a disjunction between socially anxious individuals' biological responses and their self-reported perceptions of affective states. We capitalized on this pattern in Experiment 2 by exploring if changing the way individuals appraised a stressful socially evaluative experience would result in shifts in physiological reactivity and threat vigilance.

Experiment 2

In Experiment 1 both socially anxious and nonanxious participants subjected to social evaluation exhibited a maladaptive pattern of physiological responding and greater attentional bias compared to the nonevaluation controls. These types of physiological responses impair decision making and are associated with negative health outcomes (Jefferson et al., 2010; Kassam, Koslov, & Mendes, 2009; Matthews, Gump, Block, & Allen, 1997), and attentional bias plays an integral role in the manifestation and maintenance of anxiety (Mathews & MacLeod, 2002). In Experiment 2, we tested a strategy aimed at improving these outcomes by shifting appraisals of stress arousal.

Experiment 2 used a design similar to that of Experiment 1 but replaced the no evaluation condition with a reappraisal condition. We hypothesized that reappraising arousal would yield three benefits. First, instructing participants that stress arousal is functional was expected to increase appraisals of coping resources. Second, improvements in resource/demand appraisals were expected to translate into more adaptive physiological responses. Specifically, relative to no-reappraisal controls, arousal reappraisal instructions were hypothesized to maintain SNS activation (i.e., no change in PEP) and promote approach-oriented physiological responses (i.e., decreased TPR and increased CO). Finally, we hypothesized that reappraisal would reduce attentional bias, which has implications for future experiences of anxiety.

In addition to testing the effectiveness of the arousal reappraisal manipulation, the design of Experiment 2 allowed for an exact replication of Experiment 1. That is, in the evaluative stress, no instruction condition, the physiological reactivity of socially anxious and nonanxious participants could again be compared. If we again observe no differences as a function of anxiety, we can be more confident in the conclusions from Experiment 1 that the magnitude of autonomic responses to social evaluation may not differ across the anxiety spectrum.

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Method

Participants. Participants were 73 adults (45 women, 28 men; *M* age = 25.82 years) recruited using the same procedures as described in Study 1. Participants were also asked if they were taking any prescription medications at the time of the study. Of participants, 48% reported taking medication (21 anxious, 14 nonanxious). In all, 4 participants (3 socially anxious, 1 nonanxious, all assigned to the no instruction condition) asked to stop participation prior to the conclusion of the experiment. Participants were compensated with $25.

The socially anxious group (n = 34) comprised individuals meeting diagnostic criteria for SAD according to the MINI (Sheehan et al., 1998). Nonanxious controls (n = 35) did not meet the criteria for SAD or any other anxiety or mood disorder. There were no differences between anxiety and intervention groups on age, sex, or ethnicity.

Procedure. The procedure was identical to that in Experiment 1 except that the no evaluation condition was replaced with a reappraisal manipulation. All participants were evaluated during the TSST, and socially anxious and nonanxious participants were assigned to receive either reappraisal instructions or no instructions prior to the evaluative task. The reappraisal instructions informed participants (19 anxious, 18 nonanxious) about the functionality of stress responses. Specifically, participants were told,

> In stressful situations, like public speaking, our bodies react in very specific ways. The increase in arousal you may feel during stress is not harmful. Instead, these responses evolved to help our ancestors survive by delivering oxygen to where it is needed in the body. We encourage you to reinterpret your bodily signals during the upcoming public speaking task as beneficial.

After oral instructions, participants read three summaries of scientific journal articles (that we created) outlining the positive outcomes associated with stress arousal and the adaptive benefits of stress (also see Jamieson et al., 2012). Each summary was followed by two questions that required participants to endorse the information presented before moving on.

Participants in the no-reappraisal condition (18 anxious, 18 nonanxious) were given no additional instructions and instead completed a nondemanding task (a driving game; Mather, Gorlick, & Lighthall, 2009) to control for time. Instructions and the game took 10 to 15 min to complete, after which participants completed the TSST, a recovery period, post-TSST questionnaires, and the emotional Stroop task, in that order.

Physiological measures and questionnaires. The physiological signals collected and questionnaires were identical to those in Experiment 1.

Data analytic plan. Unless otherwise noted, data were analyzed in 2 (Anxiety: socially anxious vs. nonanxious) × 2 (Intervention: reappraisal vs. no instructions) between-subjects ANOVAs. A total of 11 socially anxious participants (7 reappraisal, 4 no instructions; 33.33% of the final anxiety sample) reported past depression, and again this was included as a covariate but did not affect the results. As in Experiment 1, we also included self-reported medication status (scored as a bivariate variable) and the date since females' previous menstrual cycle as covariates. However, these covariates did not affect the pattern of results and are not reported. One participant did not fully complete the BAI, IAS, or resource/demand questionnaire, and this participant's data were excluded from those analyses. Because of a problem with the BP monitor, TPR was not computed for one participant. Three color-blind participants could not complete the Stroop task.

Results

Questionnaires

Social anxiety. As expected, socially anxious individuals exhibited higher BAI scores (M = 1.08, SD = 0.63) than their less anxious counterparts (M = 0.34, SD = 0.45), $F(1, 63) = 32.07$, $p < .001$, $d = 1.43$. The anxious participants also reported more anxiety on the IAS (M = 4.03, SD = 0.52) compared to controls (M = 2.37, SD = 0.52), $F(1, 63) = 173.20$, $p < .001$, $d = 3.32$.

Stress appraisals. Socially anxious participants reported possessing fewer resources to cope with evaluation (M = 4.12, SD = 0.87) than nonanxious participants (M = 4.84, SD = 0.69), $F(1, 63) = 14.75$, $p < .001$, $d = 0.97$. Supporting predictions, reappraisal instructions increased appraisals of coping resources (M = 4.68, SD = 0.87) relative to no instruction controls (M = 4.26, SD = 0.80), $F(1, 63) = 5.38$, $p = .024$, $d = 0.58$. There was no interaction, so the net increase in resource appraisals following reappraisal was similar across anxiety level.

Analysis of situational demands produced only a main effect for anxiety, $F(1, 63) = 35.39$, $p < .001$, $d = 1.56$. The socially anxious individuals indicated that TSST was more demanding (M = 4.58, SD = 1.09) compared to nonanxious participants (M = 3.14, SD = 0.91). In sum, the

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reappraisal manipulation boosted perceptions of coping resources, but did not affect appraisals of task demands.

Physiological measures. We first analyzed raw physiological signals (PEP, CO, and TPR) at baseline with BMI included as a covariate to examine whether baseline differences between groups might mask reactivity effects. We observed no significant effects of anxiety or intervention conditions on baseline PEP (overall $M = 111.69$ ms, $SD = 11.35$), CO (overall $M = 7.51$ l/min, $SD = 1.67$), and TPR (overall $M = 913.29$ dyne-sec/cm^{-5}, $SD = 236.48$) scores, Fs < 1.

Physiological reactivity was analyzed in 2 (Anxiety) × 2 (Intervention) × 4 (Time: preparation period vs. speech vs. mental arithmetic vs. recovery) mixed ANCOVAs with time as a within-subjects factor and BMI included as a covariate. See Table 2 for means and standard deviations.

Socially anxious participants exhibited less sympathetic reactivity overall versus their nonanxious counterparts, $F(1, 64) = 6.47$, $p = .013$, $d = 0.65$. Analysis of PEP also yielded a main effect for time, $F(1, 64) = 8.62$, $p = .005$, $d = 0.75$, with the more metabolically demanding aspects of the TSST eliciting greater SNS activation. Reappraisal had no impact on SNS activation.

Consistent with predictions, participants assigned to reappraise arousal exhibited an increase in CO versus those given no instructions, $F(1, 64) = 4.77$, $p = .032$, $d = 0.55$. Reframing arousal as functional was associated with improved cardiac efficiency. Also in accord with predictions, reappraisal participants exhibited a decrease in vascular resistance relative to their no instruction counterparts, $F(1, 64) = 9.26$, $p = .003$, $d = 0.76$.

The overall pattern of data indicates that reinterpreting stress arousal helped attenuate threat responses in anticipation of, during, and in recovery from the TSST. The PEP findings indicate that reappraisal improved responding without decreasing sympathetic activation. Moreover, none of the physiological reactivity measures produced a main effect for anxiety, nor was the Anxiety × Reappraisal interaction significant; the physiological benefits of reappraisal were observed in both anxious and nonanxious individuals.

We also explored whether improvements in appraisals predicted the change in physiology. To do so, we first computed a physiological index by averaging standardized CO and standardized, reverse-scored TPR scores (PEP is nondiagnostic of stress type). Increases correspond to adaptive physiological reactions. Higher resource appraisals measured prior to the speech were associated with improvements in physiological reactivity during public speaking for both anxious and nonanxious participants assigned to the reappraisal condition, $\beta = .326$, $p = .011$ (see the supplemental online material for additional analyses and scatterplots).

We then examined the data to determine if we replicated the null findings observed in Experiment 1. Pairwise contrasts compared PEP, CO, and TPR reactivity of anxious and nonanxious participants in the no instruction condition at every time point. The only effects approaching significance were PEP reactivity during the speech, $F(1, 64) = 2.90$, $p = .093$, $d = 0.42$, and CO reactivity at recovery, $F(1, 64) = 2.66$, $p = .108$, $d = 0.41$, but these trends suggested that socially anxious participants had *less*, not more, sympathetic activation and *better*, not

Table 2. Physiological Reactivity as a Function of Reappraisal Condition and Anxiety Level

	Preparation period		Speech delivery		Mental arithmetic		Recovery	
Condition	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
			Pre-ejection period (ms)					
No instruction, nonanxious	–10.10	7.71	–17.06	9.36	–15.59	10.14	–5.29	8.38
No instruction, socially anxious	–7.81	7.06	–12.81	7.73	–13.43	11.21	–5.94	7.79
Reappraisal, nonanxious	–15.29	9.16	–20.29	9.43	–18.24	8.09	–7.94	6.39
Reappraisal, socially anxious	–9.44	8.02	–11.67	8.04	–10.56	9.06	–5.00	8.91
			Cardiac output (liters/minute)					
No instruction, nonanxious	0.38	1.30	0.53	1.51	0.88	1.60	–0.37	0.81
No instruction, socially anxious	0.25	0.91	0.32	1.24	0.74	1.59	0.08	0.84
Reappraisal, nonanxious	0.89	0.93	1.13	1.23	1.07	1.20	0.02	0.63
Reappraisal, socially anxious	0.81	1.18	1.44	1.57	1.41	1.65	0.24	1.19
			Total peripheral resistance (dyne-sec × cm^{-5})					
No instruction, nonanxious	83.42	111.80	208.01	180.41	151.51	152.22	134.00	151.16
No instruction, socially anxious	106.11	132.09	240.10	195.23	137.21	202.30	97.59	138.56
Reappraisal, nonanxious	6.18	103.05	105.73	140.48	114.97	183.93	81.13	135.99
Reappraisal, socially anxious	28.21	158.48	49.41	166.40	37.56	171.53	7.73	93.22

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worse, cardiac efficiency versus less anxious participants, respectively (all other *p*s > .23). To further examine possible differences, we analyzed raw baseline signals. Again, no effects emerged as a function of anxiety for PEP, CO, or TPR (*p*s > .22).

Attentional bias. Analysis of attentional bias produced main effects for anxiety, $F(1, 61) = 4.22$, $p = .044$, $d = 0.53$, and reappraisal, $F(1, 61) = 7.32$, $p = .009$, $d = 0.69$ (see Fig. 2). Socially anxious individuals exhibited more attentional bias for emotionally negative information compared to less anxious participants, and participants assigned to reappraise arousal were less vigilant for threat cues compared to those not given instructions. Reframing the meaning of stress arousal decreased attentional bias similarly in both anxious and nonanxious individuals. These findings cannot be attributed to a speed-accuracy trade-off, as neither anxiety nor intervention condition influenced errors made on the threat (overall $M = 0.84$, $SD = 1.13$) or neutral lists (overall $M = 0.74$, $SD = 1.10$), *p*s > .24.

Discussion

The no-reappraisal condition in Experiment 2 served as an exact replication for the social evaluation condition in Experiment 1. Again, analyses revealed no significant differences in physiological reactivity as a function of anxiety. Just as before, though, socially anxious participants diverged from less anxious individuals in their reports of anxiety, self-report appraisals, and attentional bias. The pattern of data observed provided tentative evidence of a disjunction between physiological responses and subjective experiences in socially anxious individuals.

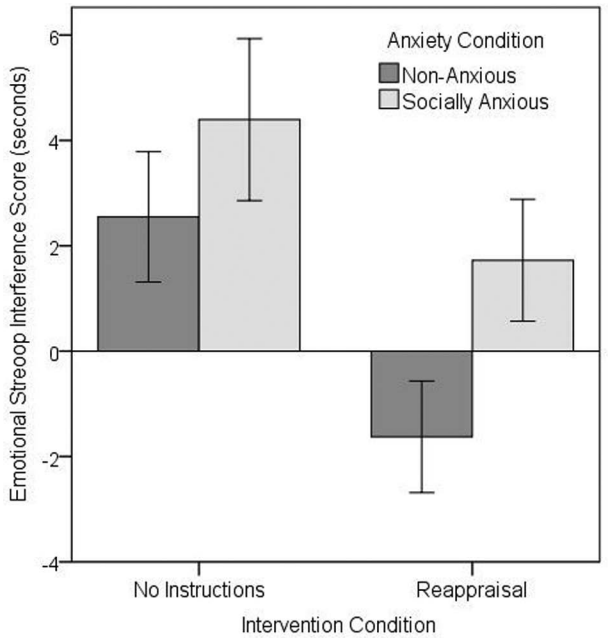

Fig. 2. Attentional bias as a function of anxiety level and intervention condition. Error bars represent +/– standard error of the mean.

It is important that Experiment 2 tested the potential benefits of a reappraisal intervention that targeted perceptions of stress arousal in SAD. Supporting predictions, both socially anxious and nonanxious participants assigned to reappraise arousal as functional exhibited improvements in resource appraisals, physiological responses, and attention. That is, reappraisal participants appraised more resources to cope with evaluation than those provided no instruction. As predicted, arousal reappraisal did affect perceptions of situational demands. That is, reappraisal participants still perceived the public speaking situation as demanding but believed they possessed greater coping resources compared to those receiving no instructions. Consistent with the stress appraisal findings, reappraisal instructions also helped to improve physiological responses to evaluative stress, while maintaining adaptive levels of sympathetic activation. Finally, reappraisal decreased vigilance for emotionally negative information, which has the potential to reduce the likelihood that individuals will experience anxiety in the future.

General Discussion

This research examined the impact of negative evaluation on physiology and attention in SAD and tested the potential benefits of reappraising stress arousal. There are two noteworthy findings from this research. First, socially anxious and nonanxious participants assigned to reappraise stress arousal exhibited increased resource appraisals, a more adaptive profile of physiological reactivity, and reduced vigilance for threat cues compared to no instruction controls. Second, no differences in physiological reactivity were observed as a function of social anxiety in either study. All participants, regardless of anxiety level, assigned to receive negative evaluation during a public speaking task exhibited a threat profile of physiological reactivity.

It may seem surprising that altering appraisals of stress arousal is sufficient to change responses to negative evaluation in SAD, but the overarching concept is not new. Theorists have speculated for years that humans can cognitively control stress responses (e.g., Schachter & Singer, 1962). Arousal reappraisal shares the same underlying theme—changing cognitions produces downstream benefits—as emotion regulation and CBT (e.g., Gross, 2003; Hofmann & Smits, 2008), but also differs in important ways from previous reappraisal-based approaches.

The aim of arousal reappraisal is not to encourage socially anxious individuals to distance themselves from threats or to reframe the meaning of anxiety-provoking

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situations, as is common in the emotion regulation literature (e.g., Kross & Ayduk, 2011; Ochsner & Gross, 2008). Nor does arousal reappraisal encourage socially anxious individuals to "relax" during evaluative situations (e.g., Beck, Stanley, Baldwin, Deagle, & Averill, 1994; Goldin & Gross, 2010; Rubia, 2009). Rather, this perspective focuses on altering perceptions of stress arousal so as to improve responses by maintaining sympathetic activation. This notion is consistent with the idea of *physiological toughness*, which suggests that SNS activation facilitates effective coping and improves performance during acute stress (Dienstbier, 1989). In more recent research, adaptive patterns of SNS responding during a TSST occurred after an intranasal dose of oxytocin, which was associated with improved social functioning (Kubzansky, Mendes, Appleton, Block, & Adler, 2012).

We must note, however, that arousal reappraisal is not a "silver bullet" for treating SAD, but is just one of the many tools clinicians have at their disposal. For instance, attentional bias and affective responses can also be modified by changing how attention is allocated, as demonstrated in the attention retraining literature. One such retraining method uses a dot-probe paradigm that instructs participants to attend to a cue that predicts the location of a nonthreatening target (e.g., Amir, Weber, Beard, Bomyea, & Taylor, 2008). By repeatedly orienting attention to neutral targets, the threat-related target loses its saliency. The subsequent reduction in attentional bias then predicts improved functioning in clinically anxious individuals (Amir et al., 2008).

Some important limitations should be considered when interpreting the current research. For one, the extant literature is not clear on the relationship between social anxiety and physiological responses to evaluative threat. In addition to methodological issues related to control groups, stress inductions, and the use of reactivity scores that the current research sought to clarify, there remain factors that warrant consideration. For one, the specific physiological measures used in a study should be taken into account. Although some SAD research has examined endocrine responses (cortisol), others, like the studies presented here, have relied on autonomic measures (e.g., vascular resistance). Though each measure has been linked to psychological threat states, there is not a "one-to-one" relationship. Although the current data provide evidence that autonomic responses to negative evaluation do not differ as a function of social anxiety, this research cannot resolve all inconsistencies in the literature. Additional work is needed to examine potential moderators.

One potentially noteworthy moderator is comorbid depression. Although efforts were made to control for depression in this research, participants did not complete a measure of depression during either experiment. That is, we were unable to quantify depressive symptoms participants may have exhibited during the study, which is potentially important as socially anxious individuals' physiological reactions to evaluation may depend on depression comorbidity (Yoon & Joormann, 2012). Future research might consider examining the potential benefits of arousal reappraisal in socially anxious individuals with and without comorbid depression.

In addition, this study cannot speak to the long-term effects of arousal reappraisal on outcomes. Rather, this research provides empirical evidence for the potential benefits of arousal reappraisal in a single-session laboratory experiment. Related to this limitation, the current research did not examine the efficacy of reappraisal outside the laboratory. It is our hope that follow-up research will extend this research to clinical settings and seek to study possible long-term benefits of arousal reappraisal in a longitudinal (or at least a multisession) design.

On a more meta level, these data suggest an approach that may help clinicians maximize the benefits of treatments. The first step in any prevention-focused treatment approach is to identify the mechanisms (biological, psychological, and situational) that underlie psychopathology. Too often intervention research is concerned only with improving outcomes rather than understanding the process that produces those improvements. The experimental procedures such as those used here are important tools that may help clinical researchers identify and test the mechanisms of change in preventative interventions (Kazdin, 2011; Kazdin & Nock, 2003).

Declaration of Conflicting Interests

The authors declared that they had no conflicts of interest with respect to their authorship or the publication of this article.

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